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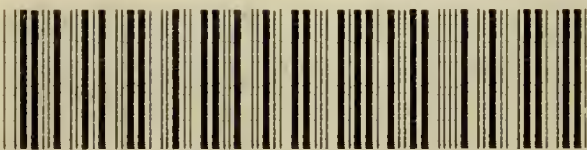
AN INTRODUCTION TO BIOLOGY.

BY

ARTHUR LOOSS, PH.D.

VOL. II.—PLATES.

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AN INTRODUCTION TO BIOLOGY.

A SERIES OF LECTURES DELIVERED TO THE
STUDENTS OF THE FIRST YEAR

BY

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NOTE.

The letters used for marking individual structures are, so far as possible, chosen from the initials of the technical names of the respective structures. About the drawings themselves compare the preface.

PLATE I.

To illustrate some details of the structure and appearance of the animal cell.

FIG. 1.—Diagrammatic drawing of a stained animal cell. *Pl* Protoplasm; the foamy structure (p. 51) is indicated, but proportionally much more enlarged than is the cell as a whole. *N* the nucleus with membrane and chromatin-network; in the meshes of the latter the cell-sap and the nucleolus *n* (further details on p. 54f). *Ct* the centrosome with the radiation starting from it (p. 56).

FIG. 2.—Diagram to illustrate the theories about the microscopical structure of the protoplasm (p. 51); *a* representing the foamy, *b* the spongy structure.

FIG. 3.—Egg-cell of a snail (p. 230) to illustrate the aspect of an animal cell in the living condition. The protoplasm is densely filled with yolk-granules (p. 173); the nucleus appears clear and hyaline (p. 53); within it, the chromatic network is faintly visible, while the two nucleoli are sharply marked (p. 55).

FIG. 4.—Stained nucleus of an Amoeba, highly magnified. The greater part of the chromatin *Cr* represents an almost solid body in the centre, around which the achromatin forms a clear halo traversed by linin-fibres with some chromatin-grains attached to them (p. 58). *Pl* cytoplasm surrounding the nucleus.

FIG. 5.—Highly magnified drawing of a stained nucleus, to show the slightly coloured linin-fibres with the intensely coloured chromatin-grains *Cr* attached to them (p. 54f). *n* the nucleolus.

FIG. 6.—Preserved and stained epithelial cell of the spinning glands of a silk-worm (p. 188) as an example of a cell with ramified nucleus (p. 53).

FIG. 7.—Diagrammatic drawing of a pigment-cell to illustrate description on p. 71. The cytoplasm is so densely filled with coloured granules that the nucleus only shines through as a lighter area. The processes of the cellular body may, on the one hand, be extended so as to reach several times their actual length, and may, on the other, be withdrawn so as to almost entirely disappear.

FIG. 8.—Diagrams of leucocytes (p. 68f). *a* leucocyte of a frog, living and in motion, with several blunt pseudopodia. The irregularly shaped, but little marked nucleus lies to the right, while the protoplasm encloses an incorporated *Bacillus* surrounded by a food-vacuole (p. 66). *b* a leucocyte of Man, preserved and stained. The pseudopodia are almost withdrawn; the nucleus is intensely coloured and exhibits a characteristic irregular shape.

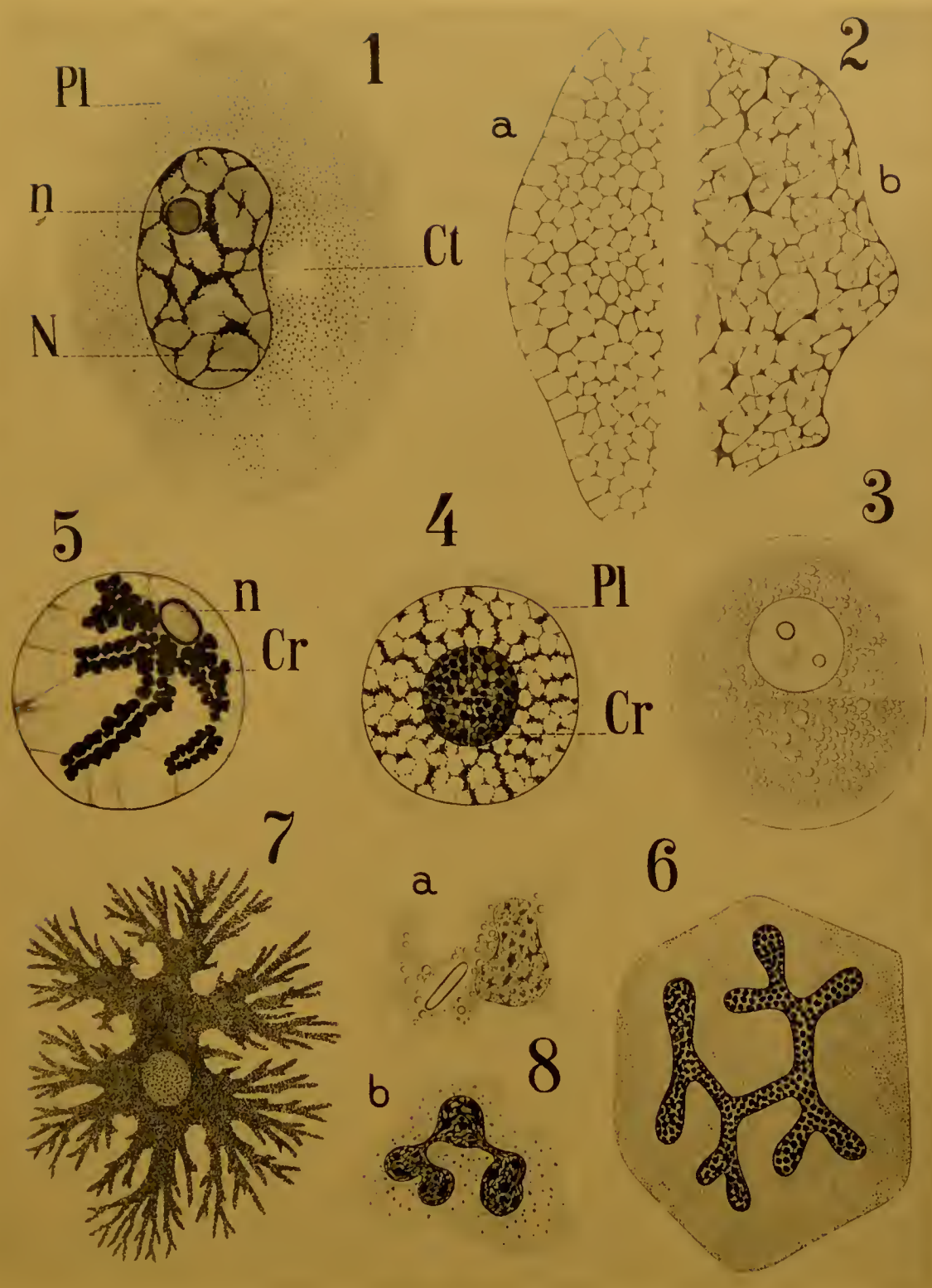


PLATE II.

To illustrate the structure and life-history of *Amoeba* (pp. 60-69, 149-152).

FIGS. 1-2.—The structure of *Amoeba*.

FIG. 1.—Living specimen of *Amoeba proteus* (p. 238). The numerous pointed pseudopodia *Ps* consist almost entirely of clear ectoplasm. The granular entoplasm, owing to the presence of the numerous vacuoles *V*, is strongly vacuolised. Within it, we see the nucleus *N* with central chromatic body (Fig. 4, Pl. I) and surrounding clear halo, the contractile vacuole *cV*, and three incorporated Algae, two of which are surrounded by food-vacuoles *fV* (p. 65).

FIG. 2.—*Amoeba limax* (p. 238), living and in motion. There is only one rounded pseudopodium *Ps*, into which the granular entoplasm is just on the point of entering. *cV* contractile vacuole, *N* nucleus, in this case not clearly divided into central chromatin-body and peripheral halo. In the entoplasm eight incorporated bacteria.

FIGS. 3-4.—Diagrams illustrating the simple division.

FIG. 3.—Preserved and stained *Amoeba* in an initial phase of division; for details of the process see description on page 68. *V* vacuoles.

FIG. 4.—Similar *Amoeba* shortly before completion of the division; for details see page 68.

FIGS. 5-8.—Diagrams illustrating the multiple division.

FIG. 5.—Preserved and stained specimen with the chromatin broken up into eight portions which have arranged themselves along the surface of the nucleus. As to the scientific interpretation of this stage see page 151.

FIG. 6.—Similar specimen in the multinuclear stage.

FIG. 7.—Living encysted specimen in the commencement of the division of the cytoplasm.

FIG. 8.—Similar specimen with eight small *Amoebae* as the result of the accomplishment of the division. For details about Figures 6-8 compare page 151f.

FIG. 9.—Diagram of *Arcella vulgaris* as an example of an *Amoeba* enclosed in a horny shell (p. 77). The latter is hemispherical in shape, with a round opening in the flattened (lower) surface, through which the pseudopodia are sent forth. The organisation is that of an ordinary *Amoeba*; *Ps* pseudopodia, *cV* contractile vacuule, *fV* food-vacuoles, *N* nucleus.

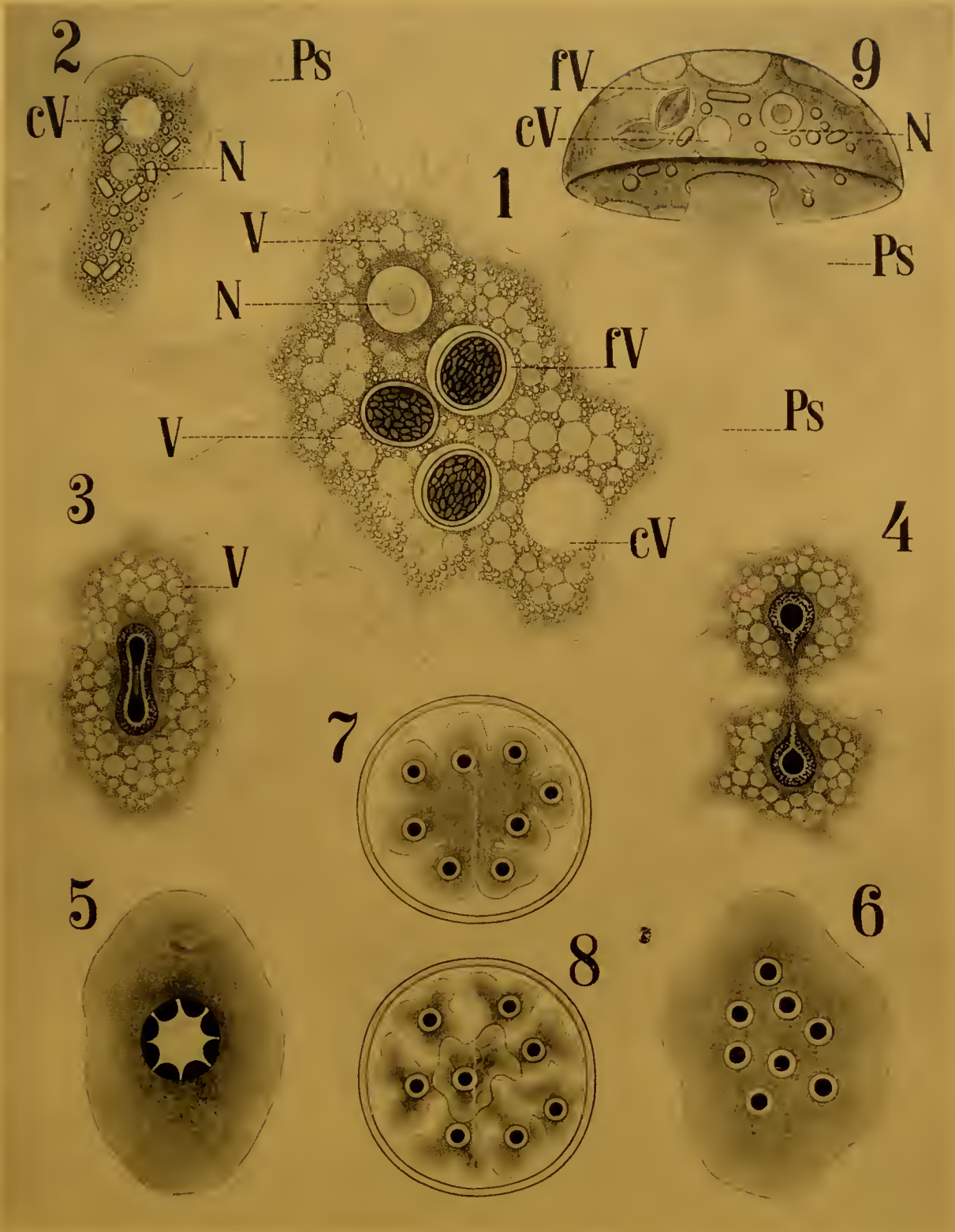


PLATE III.

FIGS. 1-5.—Diagrammatic drawings to illustrate the description of *Vorticella* on pages 79-89.

FIG. 1.—A full-grown living *Vorticella*. The posterior portion of the stalk *St* is still coiled, while the anterior portion is in the act of being uncoiled. Within the stalk the contractile band is seen. Between stalk and body proper lies the socle-like portion (p. 82) with the longitudinal myonemata *My*; similar myonemata running in a circular direction are visible—but not marked—as fine transverse lines just under the pellicule of the body proper. *Cph* the cytopharynx (p. 103); two bacteria have just entered it, while a fresh food-vacuole *fV** is on the point of detaching itself from its bottom (p. 88); five older food-vacuoles *fV*, filled with various microorganisms, are on their way through the body. *cV* the contractile vacuole. *N* the horseshoe-shaped nucleus, with one arm turned towards the observer, the other away from him.

FIG. 2.—A pair of young *Vorticellae* arisen by the division of a mother-individual. The specimen to the right shows the posterior crown of cilia; for further details see description on page 90.

FIG. 3.—Diagrams to show the formation of colonies by incomplete division (for details see description on page 91f).

FIG. 4.—Diagram to show the formation of the male (micro-) gametes by two consecutive divisions of a mother-individual. All four gametes exhibit the attributes of mobility in the shape of a posterior crown of cilia (p. 94).

FIG. 5.—Diagram to illustrate the copulation. One of the small individuals of Fig. 4 has settled on a large (undivided) specimen (a macrogamete) in order to eventually fuse with it (for further details see pp. 94 and 131).

FIGS. 6 and 7.—Diagrams to illustrate the structure and division of *Paramecium*.

FIG. 6.—A living *Paramecium* (compare description on p. 95f). *Cst* the cytostome, *Cph* the cytopharynx, *cV1* and *cV2* the two contractile vacuoles, *ccV* the canals in the protoplasm leading to them; *fV* the food-vacuoles; *Mi* and *Ma* the micronucleus and macronucleus respectively.

FIG. 7.—A *Paramecium* during the process of division (see description on p. 127). Cytostome *Cst* and cytopharynx *Cph* have become doubled; a new contractile vacuole (*cV1II* and *cV2II*) has been formed beside each of the old (*cV1I* and *cV2I*); while the macronucleus *Ma* shows no noticeable change in its structure, the micronucleus *Mi* exhibits minute chromatic bodies recalling chromosomes. Both nuclei and the body proper show the median constriction indicative of the division.

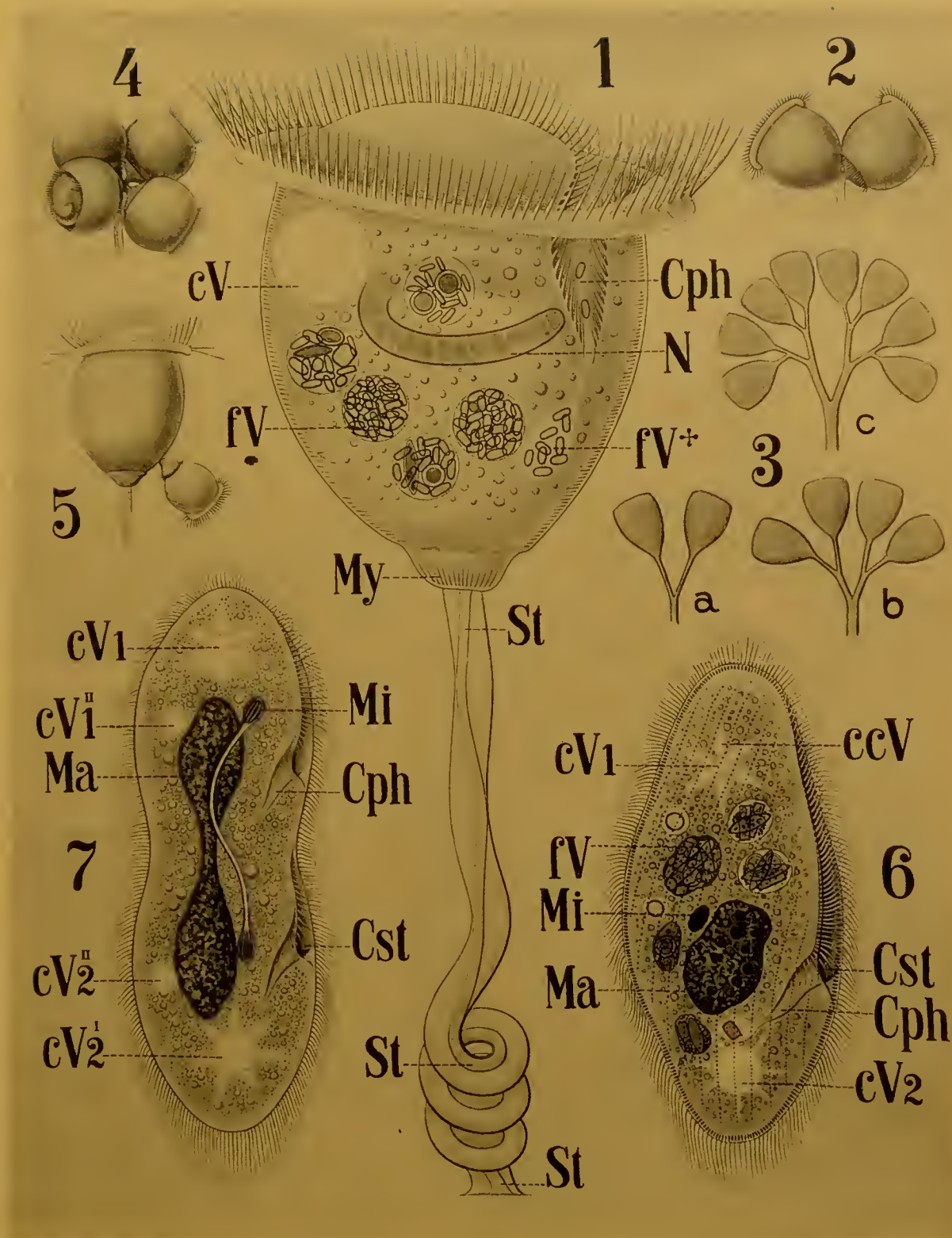


PLATE IV.

FIG. 1.—Diagram of a working Vorticella to illustrate the experiment described on page 83. The whirl produced in the water by the ciliary apparatus is rendered visible by the addition of the colour-grains; the arrows indicate the direction in which these grains move.

FIG. 2-4.—To illustrate the characteristic distinctions between the Orders of the Ciliata (pp. 95-103 and Table opposite p. 229).

FIG. 2.—Diagram of a species of *Opalina* (p. 94). *N* the numerous nuclei resembling one another in size and shape. No mouth-opening or other organula are developed.

FIG. 3.—Diagram of a species of *Balantidium* (p. 96). *Cst* the cytostome, *cV* a contractile vacuole, *Cp* the cytoppyge (here situated at the end of the body), through which a food-vacuole is just on the point of emptying its contents. Within the body, but not specially marked, there are visible two food-vacuoles, another contractile vacuole, and the sausage-shaped macronucleus with a small micronucleus close to its concavity.

FIG. 4.—Diagram of a species of *Stylonychia* (p. 97), seen from the ventral aspect. Besides the cilia, it exhibits a number of cirri, in part straight, in part slightly curved. The cytostome *Cst* is very wide and gaping; near its bottom, there appear two delicate undulating membranes (p. 96). *cV* the contractile vacuole; the elongated white spaces above and below it are collecting canals such as marked *ccV* in *Paramaecium* (Fig. 6, Pl. III). *V* a large food-vacuole with several smaller ones in its neighbourhood; all are filled with various microorganisms. *Cp* the cytoppyge situated on the dorsal side, *i.e.* the side turned away from the observer; a small rod-shaped Alga is just being voided through it. In the cytoplasm. we see, not specially marked, the two pairs of nuclei distinctive of *Stylonychia*.

FIG. 5-7.—To illustrate the structure and reproduction of the Acinetans (pp. 93-94).

FIG. 5.—Diagram of an Acinetan (*Podophrya fixa*), to illustrate description on page 93. The round body, fixed to its support by a short stalk (below), carries the characteristic processes: in the body, we see a contractile vacuole *cV* and a (macro-) nucleus *N* with a small micronucleus close to its wall.

FIG. 6.—Specimen of another Acinetan (*Podophrya gemmipara*) in the act of budding. The knobbed processes have been withdrawn; from the anterior aspect six buds *B* have grown out, each pushed by a portion of the (ramified) nucleus *N*. For further details see description on page 93f.

FIG. 7.—One of the detached buds preparing, after a period of vagrant life, to settle again on some support. Between the cilia, a number of the characteristic knobbed processes, as yet short, have made their appearance. *cV* contractile vacuole. *N* nucleus. compare also description on p. 94).

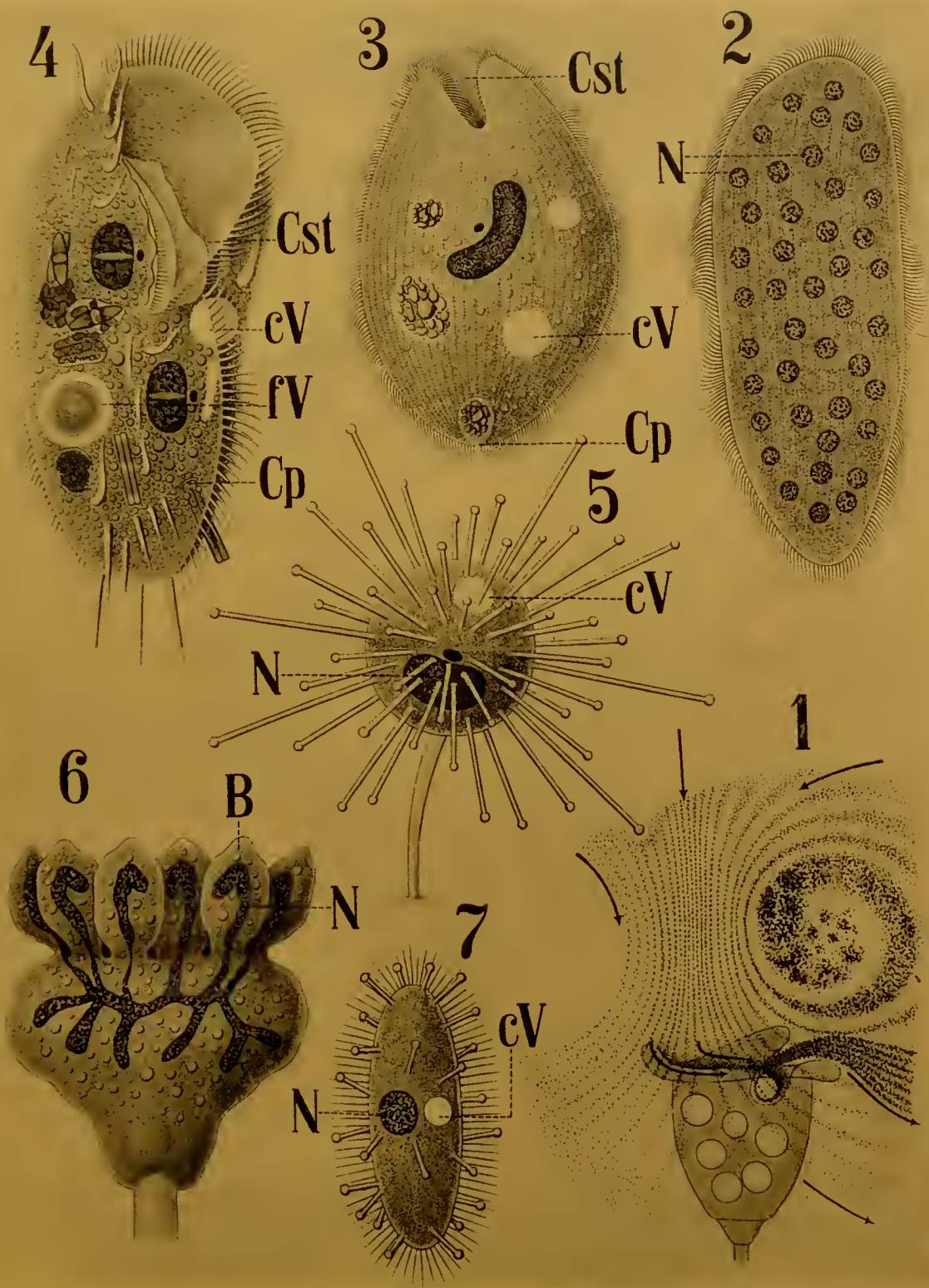


PLATE V.

To illustrate the mitotic division of the nucleus described on pages 108-111. Figures 1-3, preparation for the division; Figure 4, Metakinesis; Figures 5 and 6, reconstruction of the nuclei.

FIG. 1.—The chromatin has arranged itself into a continuous, as yet long and thin thread; the nucleolus has disappeared; the nuclear membrane is becoming faint; the centrosome has divided into two, the radiation between the daughter-centrosomes is beginning to appear.

FIG. 2.—The chromatin has become broken up into short thick chromosomes which begin to collect in the middle; the nuclear membrane has completely disappeared; the centrosomes, in their movement apart, have almost arrived opposite each other; the radiation starting from them, and composing the spindle, is very clear.

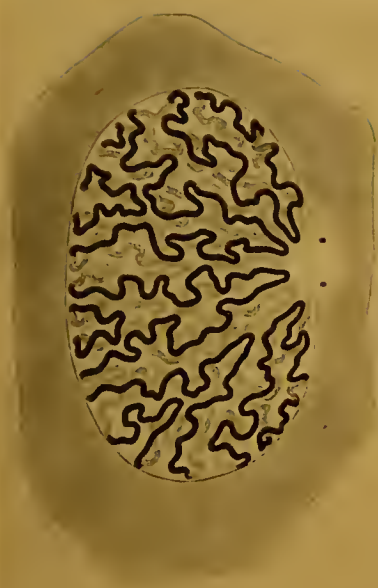
FIG. 3.—The aster-stage. The chromosomes have taken up their regular arrangement in the median plane and have become split longitudinally; the centrosomes lie exactly opposite each other in the axis of the spindle; the radiation starting from them and the spindle are at the height of their development (for the sake of greater clearness, the plane in which the chromosomes lie, and which in reality forms right angles with the axis of the spindle, has been drawn somewhat inclined towards the observer).

FIG. 4.—The two halves of each chromosome are moving asunder, the separation having commenced at the angles, while the free ends are still seen lying side by side.

FIG. 5.—The amphiaster-stage. The two sets of half-chromosomes are completely separated and lie near their respective centrosomes, the angles pointing towards these. The chromosomes themselves commence to become shorter and thicker, radiation and spindle are growing fainter.

FIG. 6.—The cytoplasm is divided. The presence of the two daughter-cells has been utilised for showing, in the upper, an earlier, in the lower, a later stage in the reconstruction of the nuclei. Above, the chromosomes have lost their regular arrangement and are beginning to also lose their regular shape; the nuclear membrane is reappearing; the centrosome is still visible, but the radiation has faded away. Below, nuclear membrane, nucleolus and linin fibres have reappeared; the chromosomes are disintegrating; the centrosome is no longer perceptible.

1



2



3



4



5



6



PLATE VI.

Diagrams to illustrate the descriptions of the maturation of the egg-cell (pp. 115-117), the development of the spermatozoa (pp. 117-118), and the internal phenomena of fertilisation (pp. 179-182), in *Ascaris megalocephala*.

FIGS. 1-5.—Upper halves: maturation of the egg-cell.

FIG. 1.—Immature egg-cell, or oocyte. The nucleus, still lying in the centre, shows two groups, each of four chromosomes; two centrosomes are lying outside, close to the nuclear membrane.

FIG. 2.—The nucleus has moved to the surface of the cell and prepares for the first (ordinary mitotic) division.

FIG. 3.—The division has taken place; one half of the chromosomes have been removed in the first polar body; the chromosomes of the remaining half begin to segregate into two groups, guided by the centrosome which has divided previously; a new spindle is being formed between the daughter-centrosomes.

FIG. 4.—Second (reducing) division. The new spindle is fully developed; the daughter-stars now each contain only half the previous number of chromosomes.

FIG. 5.—One of the daughter-stars has been removed in the second polar body; the egg-cell remains with half the original and normal number of chromosomes, and is in this state mature.

FIGS. I-VI.—Development of the spermatozoa.

FIG. I.—Spermocyte, containing in its nucleus two groups of four chromosomes each, and, outside the nuclear membrane, two centrosomes. Stage corresponding to Figure 1.

FIG. II.—Preparation for the first (ordinary mitotic) division. Stage corresponding to Figure 2.

FIG. III.—The division has taken place. The drawing shows two phases of the development that follows; in the upper cell, the chromosomes are still seen to show their previous arrangement, but the centrosome has divided. In the lower cell, the daughter-centrosomes, while moving further apart, are seen to separate the chromosomes into two groups consisting each of half the original number. This latter stage corresponds to Figure 3.

FIG. IV.—The two descendants of the spermocyte prepare for the second (reducing) division; the daughter-stars are now each composed of only half the previous number of chromosomes. Stage corresponding to Figure 4.

FIG. V.—The division is nearly accomplished. In the upper group of two, the chromosomes are seen in their previous condition; the lower group shows them in a somewhat later stage, i.e. beginning to contract and to approach each other.

FIG. VI.—The four spermatozoa derived from the spermocyte, fully formed; in each the chromosomes have become blended into a solid chromatin-grain, while the centrosomes have disappeared.

FIGS. 1-6.—Lower halves: the internal phenomena of fertilisation.

FIG. 1.—A spermatozoon (for its description see p. 117) has come into contact with, and is entering into, the egg-cell. Its nucleus and protoplasm, in order to differentiate them from the corresponding parts of the egg-cell, are shaded in dots.



PLATE VI (*continued*).

FIG. 2.—The spermatozoon consisting, as before, of cytoplasm, nucleus, and centrosome, is seen in the egg-protoplasm; only the conical body has disappeared.

FIG. 3.—The cytoplasm of the spermatozoon has vanished, centrosome and nucleus are lying free in the egg-protoplasm; the nucleus has imbibed fluid and its chromatin has reassumed the shape of distinct chromosomes.

FIG. 4.—The nuclear membrane of the spermatozoon has disappeared, leaving the chromosomes free in the egg-protoplasm, while a radiation begins to start from the centrosome.

FIG. 5.—The second polar body has been extruded from the egg-cell; in the cytoplasm of the latter, there now lie two groups of chromosomes, viz., one of male and one of female origin; both gradually stretch to assume the ordinary loop-shape; the female centrosome is no longer discernible.

FIG. 6.—Preparation for the first division of the fertilised egg-cell. The male centrosome has divided, the products of the division have moved asunder, a spindle has developed between them; all the chromosomes have taken their position in the middle of, and at right angles to, the axis of the spindle, and have become halved longitudinally—the conditions are thus exactly the same as those in Fig. 3, Pl. V. During the following metaphase, each daughter-cell will accordingly receive half of every male and half of every female chromosome, and so on in all further divisions of the descendants of the egg-cell.

PLATE VII.

Diagrams to illustrate the conjugation of *Paramaecium*, described on pages 127-131.

FIG. 1.—Pair in the beginning of the process. The macronucleus *Ma* shows irregular outlines; the micronucleus *Mi*, by imbibing fluid, has become swollen; its chromatin is arranged in a manner recalling the diaster-stage (Figs. 4-5, Pl. V). (The right-hand-individual of the pair is not fully drawn, as it would show quite similar conditions.)

FIG. 2.—Somewhat further advanced pair (the left-hand-individual of which is omitted). The irregularity in the outlines of the macronucleus has increased; the micronucleus has accomplished its first division and is preparing for the second. Of this, $\frac{Mi}{2}$ shows an earlier stage (corresponding to that of *Mi* in Fig. 1) while $\frac{Mi}{4}$ is a later stage, in which the two (grand-daughter-) nuclei have separated and moved asunder, but are still united by the characteristic strand (Note therefore that the figure is a combination, showing side by side two stages of nuclear division, which in reality occur one after the other).

FIG. 3.—Exchange of the nuclear material through the "bridge" (note the interruption in the line separating the two individuals). The macronucleus is beginning to detach small pieces from its mass. Of the four (grand-daughter-) micronuclei, three have remained inactive, and even commenced to disintegrate ($\frac{Mi}{4}$); the fourth has divided once more ($\frac{Mi}{8}$); one product of this division is still seen at its original place, while the other, still connected with its mate by the characteristic strand, has passed over into the other individual through the bridge. Both parts subsequently separate completely; in order to mark their common origin even then, the nuclear material belonging to the left-hand-individual is in the figures shaded in uniform black, while that belonging to the right-hand-individual is shaded in dots. The diagram shows that, after the completion of the migration and the separation of the nuclei, each conjugating individual has one nuclear half left which is its own (and is therefore interpreted as the female equivalent, ♀), while, in exchange for the half given away, it received a corresponding half which was passed over from the associate (and is therefore interpreted as the male equivalent, ♂; compare p. 131).

FIG. 4.—Combination, showing a pair which prepares for re-separation, as indicated by the reappearance of the separation-line at the place of the "bridge"; of the two constituent individuals, the one to the left is represented in an earlier, the other in a somewhat later stage of the process. In both the disintegration of macronucleus *Ma* and the three inactive quarters of the micronucleus $\frac{M}{4}$ has advanced further. In the left-hand-individual the male (♂) and female (♀) equivalents of the active nuclei are seen lying side by side, but still separated; in the right-hand-individual, they have become blended into one body $N \begin{smallmatrix} \nearrow \\ + \end{smallmatrix}$ which is preparing for division after the fashion of *Mi* in Figure 1; the different origin of its chromatic material is indicated as before by the respective shading,

FIG. 5.—Individual after separation, showing the first division of the new nucleus (*N-N*), by which the two constituent varieties of chromatin are equally distributed between the daughter-nuclei. The original macronucleus has broken up into a large number of small pieces *Ma*, amongst which the three inactive quarter-micronuclei $\frac{Mi}{4}$ cease to be clearly recognisable.

FIG. 6.—Individual reassuming the usual appearance and structure of the species. One of the half-nuclei $\frac{N}{2}$ of Figure 5 is swelling up into a new macronucleus *Ma**, while the other half shrinks to form the new micronucleus *Mi**.

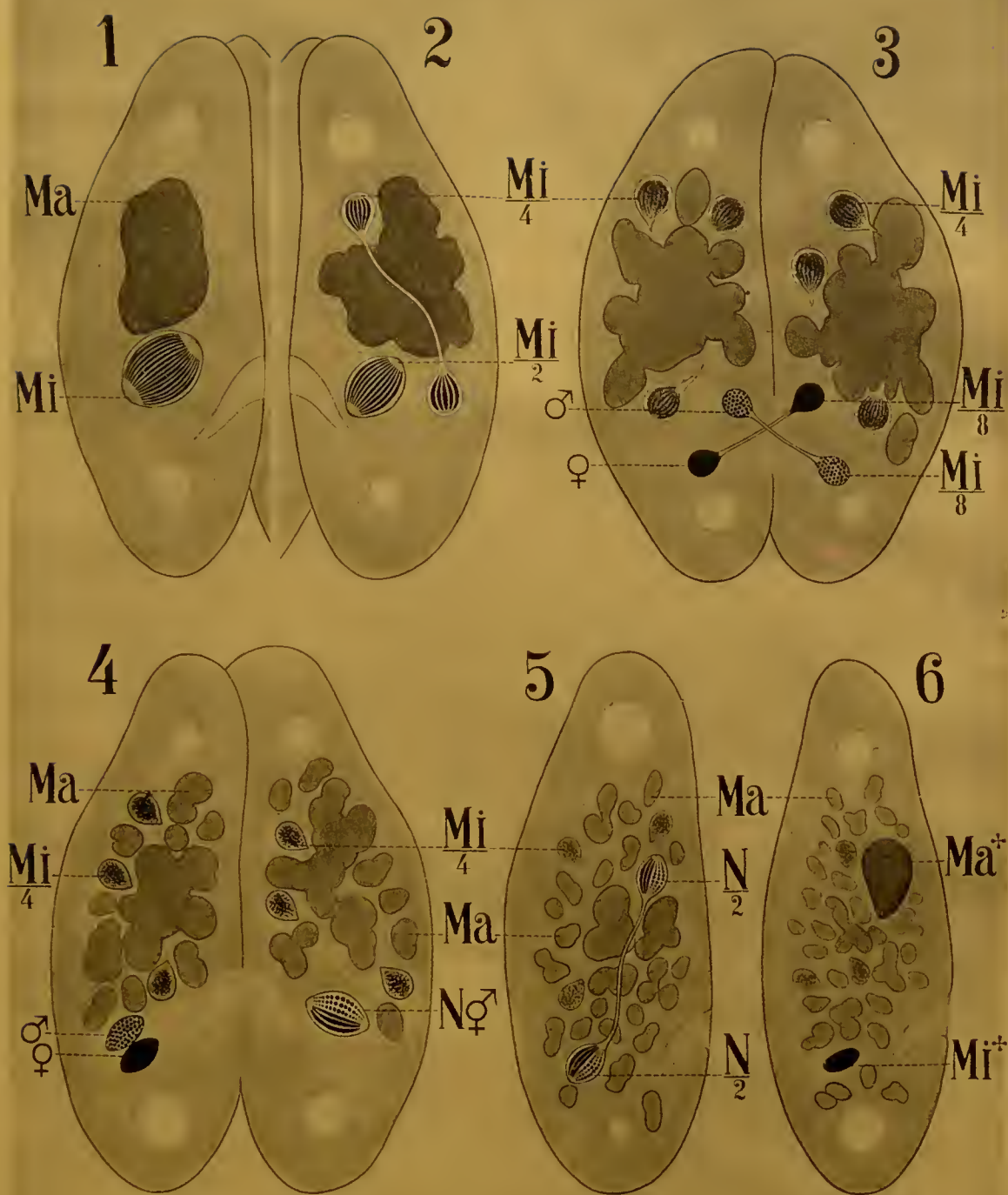


PLATE VIII.

To illustrate the structure and life-history of the Gregarinida, described on pages 132-139.

FIG. 1.—Diagram to show the characteristics of the Genus *Monocystis*: apart from the well-marked pellicule, the underlying thin layer of ectoplasm, and the coarsely granular entoplasm with the vesicular nucleus enclosing one nucleolus—no partition-wall (p. 133).

FIG. 2.—Diagram to show the characteristics of the genus *Gregarina* (p. 133): apart from the structures mentioned—a partition-wall, consisting of ectoplasm and dividing the body into an anterior protonerit *Pr* and a posterior deutomerit (not lettered).

FIG. 3.—Diagram to show the characteristics of the genus *Stylorhynchus* (p. 133): apart from the structures mentioned—the prolongation of the protonerit into the epimerit *Ep*. In the deutomerit *De* a fairly large nucleus with several nucleoli.

FIG. 4.—Two individuals, attached to each other in the characteristic manner (p. 134), but as yet still free.

FIG. 5.—Two similar individuals, contracted and surrounded by a cyst *Cy*.

FIGS. 6-8.—Three phases out of the further changes going on within the cyst. In the omitted parts of each cyst the conditions would have been the same as those which are actually seen in the part depicted.

FIG. 6.—Quarter of a cyst, showing half of the upper individual; the body has assumed an irregular shape; the nucleus, by a number of successive divisions, has become broken up into numerous small nuclei which have arranged themselves along the surface and begin to collect a layer of clear protoplasm round them.

FIG. 7.—Quarter of a cyst, showing half of the lower individual in a somewhat more advanced stage. The irregularity in the shape of the body has increased; the superficial layer of clear protoplasm with the nuclei enclosed in it has become transformed into small cells which now also separate themselves from the underlying granular residual body.

FIG. 8.—Half of a cyst in which the descendants of the upper individual have developed into microgametes, those of the lower individual into macrogametes. The former, after having severed their connection with the residual body, are seen to move about in the cyst and to seek the macrogametes in order to copulate with them.

FIG. 9.—A microgamete, and

FIG. 10.—A macrogamete of *Stylorhynchus*, more highly enlarged, to show their sexual distinctions; although their size is not very different, the microgamete yet exhibits the attributes of mobility in the shape of the long flagellum which is absent in the macrogamete. These gametes are therefore an example of Heterogametes (p. 254). Internally, both varieties possess a clear round nucleus with a brilliant nucleolus, and a number of small vacuoles in the cytoplasm.

FIG. 11.—A newly formed "spore" of *Gregarina*. Within the bluntly spindle-shaped shell there lies the zygote, i.e. a macrogamete and a microgamete completely fused into one cell.

FIG. 12.—A fully developed "Pseudonavicelle" from the cysts of *Monocystis* (p. 137). Within the (somewhat boat-shaped) wall of the spore the original zygote, by three successive divisions, has developed into eight slender sporozoites *Sz*.

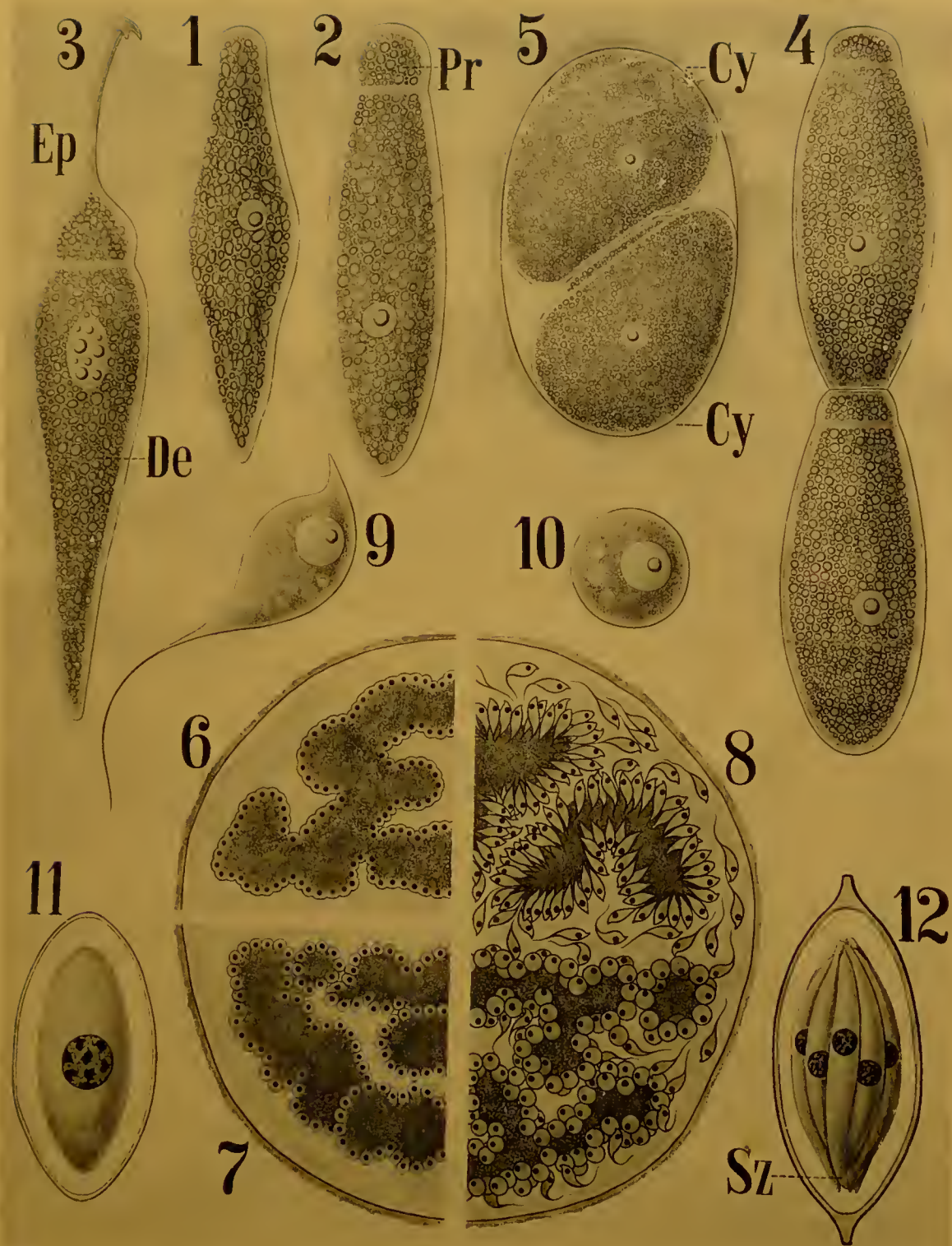


PLATE IX.

To illustrate the structure and life-history of the Malaria-parasites, more in particular that of *Plasmodium vivax* (see description pp. 139-149). The stages which follow, or may follow, each other are connected by small arrows.

FIG. 1.—A young *Plasmodium* recently entered into an erythrocyte. Note the small round nucleus, the clear food-vacuole to one side of it, the wavy outlines of the cytoplasm indicative of amoebic movement, and the few pigment-grains (p. 140).

FIG. 2.—A nearly full-grown *Plasmodium* (or a schizont) preparing for division. Note the loose arrangement of the chromatin in the nucleus and the swelling, combined with paling, of the infected erythrocyte.

FIG. 3.—A further advanced schizont. The food-vacuole has disappeared; the nucleus has divided twice, the lower descendant to the right is preparing for a third division; the pigment-granules are beginning to accumulate in the middle. The degenerative changes in the aspect of the erythrocyte are more marked.

FIG. 4.—Schizont ready to break up into merozoites. The infected erythrocyte is on the point of disintegrating altogether.

FIG. 5.—The multiple division (schizogony) has taken place. In the middle between the young merozoites lies the residual body containing the (now numerous) pigment-granules. The erythrocyte has been dissolved.

FIG. 6.—The merozoites enter erythrocytes, as indicated by the arrow connecting Figure 5 with Figure 6, and the schizogony becomes repeated.

FIGS. 7♂ — 9♂.—The development of merozoites into microgametocytes. For their differential characters see page 142.

FIGS. 7♀ — 10♀.—The development of merozoites into macrogametocytes; for their differential characters see page 142. Both micro- and macrogametocytes, during their development, destroy the occupied erythrocytes, as did the schizonts. The dotted line below Figures 9♂, 9♀, and 10♀ indicates that the further developmental stages occur in the stomach of the mosquito, part of the wall of which—composed of a single layer of epithelium-cells and a basement-membrane (p. 143)—has been drawn in cross-section and in continuance with the dotted line.

FIG. 10♂.—A microgametocyte with eight nuclei scattered in the cytoplasm.

FIG. 11♂.—Formation of the microgametes. The nuclei have drawn near the surface and have collected cytoplasm round them (see nucleus quite to the left), which gradually assumes the shape of a long lively beating flagellum. The lowermost gamete has just become detached from the mother-cell (p. 142).

FIG. 11♀.—The maturation of the macrogamete (p. 142).

FIG. 12.—The copulation, as indicated by the sign ♂₊. A microgamete has reached the macrogamete; its nucleus has already entered the latter, while the flagellum is still free. The extruded "polar body" lies close by.

FIG. 13.—The zygote, showing its characteristic elongated shape. The male and female nuclei within are still separated.

FIG. 14.—The zygote makes its way into the intestinal epithelium of the mosquito. Note that this figure, as well as those up to Figure 20, are considerably less enlarged than are the preceding figures.

FIG. 15.—The zygote has come to rest between the epithelium and the basement-membrane of the intestinal wall. The very thin cyst of its own, which it secretes round itself, merely appears as a fine line (so also in the following figures).

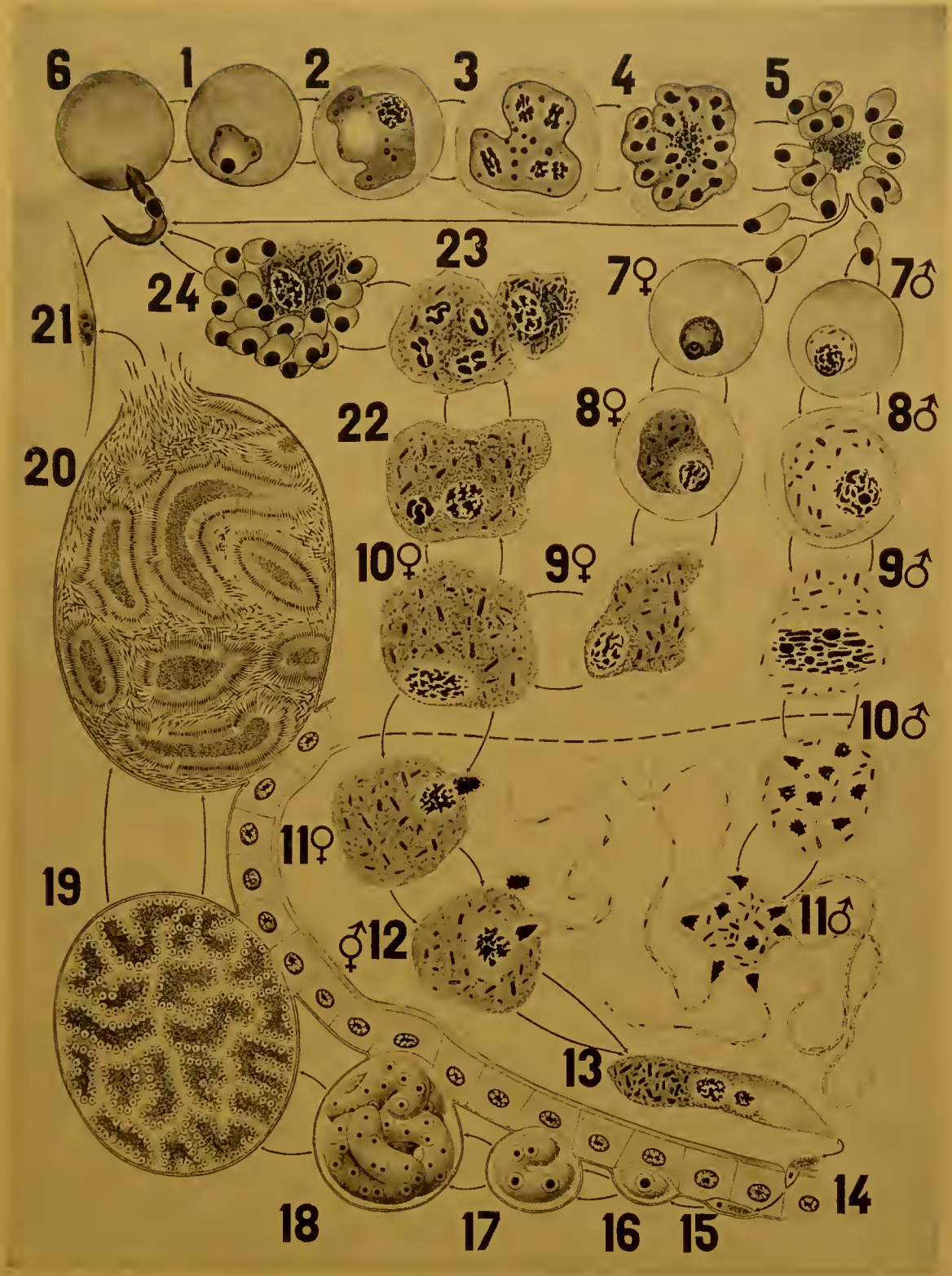


PLATE IX (*continued*).

FIG. 16.—Beginning enlargement of the zygote.

FIG. 17.—The zygote has assumed a sausage-shape, bulging the basement-membrane ever more markedly outwards; the divisions of the nucleus have commenced.

FIG. 18.—The zygote, on account of its continued lengthening, is forced to irregularly coil up in its cyst. The nuclei have become numerous.

FIG. 19.—A further advanced zygote, as it presents itself in sections; the coils cut through appearing as isolated pieces. The nuclei have come to the surface and have transformed themselves into cells after the same fashion as that shown by Figures 6, 7, Plate VIII.

FIG. 20.—A mature cyst still attached to the intestinal wall by the considerably dilated basement-membrane. The small cells of Figure 19 have developed into slender spindle-shaped sporozoites, in part still continuous with the residual body, in part detached from it. As indicated in the Figure, they subsequently escape into the abdominal cavity of the mosquito by rupture of the cyst and the basement-membrane fixing it to the intestinal wall.

FIG. 21.—A free sporozoite under the same enlargement as Figures 1-13. If transferred into a man it enters an erythrocyte as shown in Figure 6.

FIGS. 22-24.—The retransformation of macrogametocytes (Fig. 20♀) into schizonts (compare description on p. 147).

FIG. 22.—The division of the nucleus.

FIG. 23.—The subsequent division of the cell into an active and an inactive portion. The former is already seen to prepare for schizogony by divisions of its nucleus.

FIG. 24.—The schizogony has taken place; amidst the young merozoites lies the inactive portion of the original macrogametocyte with the (presumably) sexual portion of the nucleus enclosed in it.

PLATE X.

FIGS. 1-5.—To illustrate some of the chief variations which occur among the sexual cells of animals.

FIG. 1.—Various forms of spermatozoa, to illustrate the description on page 171. *a* of a mammal (surface- and side-view), *b* of a bird, *c* of an Amphibian, *d* of a snail. In *a* and *c* the middle-pieces are fairly well marked; *c* possesses all along its tail an undulating membrane; *d* at its posterior end has several short flagella in place of the usual single and long flagellum. *e* and *f* are two examples of the aberrant shapes found in the spermatozoa of Crustacea.

FIGS. 2-5.—Various forms of egg-cells (pp. 172-177).

FIG. 2.—Centrolecithal egg-cell of a Nematode (as, e.g. *Ascaris megalocephala*, p. 175).

FIG. 3.—Telolccithal egg-cell of a frog in optical section. The nucleus *N* is surrounded by protoplasm comparatively free from yolk-granules, while the lower part of the cell is densely filled with them.

FIG. 4.—Telolecithal egg-cell of a bird in optical section. The nucleus *N* lies, quite to the surface of the cell, in a small area of protoplasm free from yolk (germinal disc, p. 176), all the rest of the cell is filled with it. The yolk, in the birds' eggs, permits one to distinguish two varieties: one of these, of a distinctly yellowish tinge, is arranged in concentric layers (which appear blackish in the drawing); the other, chiefly accumulated in the centre, has a whitish colour.

FIG. 5.—Egg-cell of a frog in surface-view, to show the difference in the colouration of the two poles (p. 176).

FIGS. 6-8.—To illustrate the external phenomena of fertilisation as observable in the sea-urchins (see description on p. 177f).

FIG. 6.—Superficial portion of an egg, with the mucous envelope covering it, and a number of spermatozoa in the neighbourhood. The reception-hill is sent forth in their direction.

FIG. 7.—One of the spermatozoa has entered the mucous envelope and has come into contact with the reception-hill. The vitelline membrane is being formed between the surface of the egg-cell and the mucous envelope.

FIG. 8.—The reception-hill has been withdrawn, the head of the spermatozoon is lying in the egg-protoplasm (the tail, somewhat shrunken, still outside it); the vitelline membrane is fully developed. The spermatozoa outside, with the exception of three, have dispersed.

FIG. 9.—The rotation of the head of the spermatozoon after its entrance into the egg-cell (p. 178f). *a* the head in the original position, the middle-piece lying behind it, the reception-hill (through which it entered) being still distinctly visible; *b* head and middle-piece lying about transversely to their previous direction; the reception-hill is sinking in; *c* the middle-piece lies in front of the head and detaches itself from it; the radiation is beginning to appear; *d* a distinct centrosome is visible at the place of the former middle-piece, the radiation starting from it has become very marked; the head is beginning to swell (preparation for the reappearance of the chromosomes); the reception-hill has vanished.

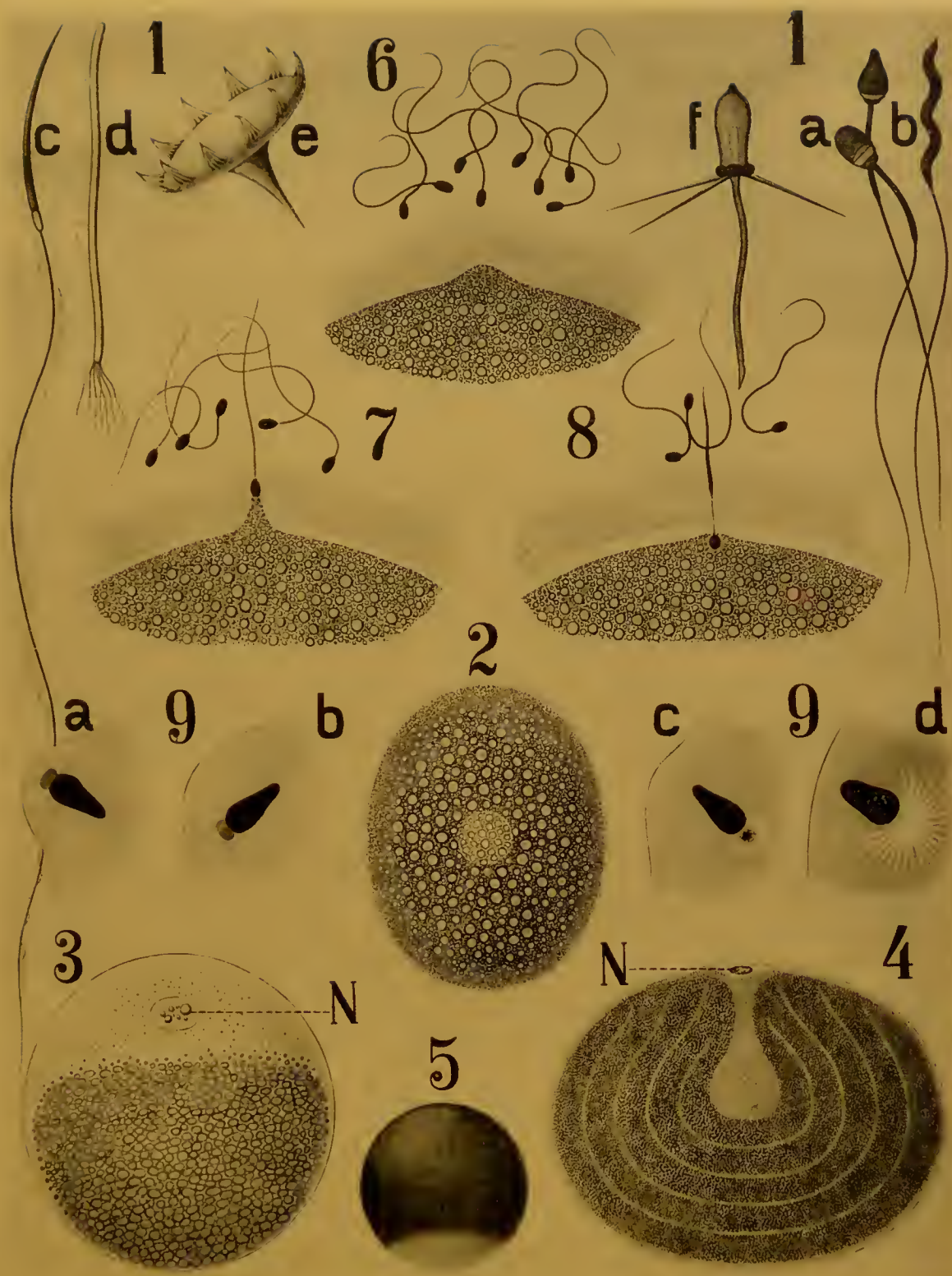


PLATE XI.

To illustrate the life-history of the Trematodes, described on pages 200-203.

FIG. 1.—Diagram of a free-swimming miracidium of the African Liver-fluke. We see the cilia, covering the body with the exception of a small “proboscis” at the anterior end; on the tip of this a rudimentary intestine (dark in the drawing) opens; behind it, there lies a round mass of small cells representing a nervous centre, with two black eye-spots on its surface; in the body-wall enclosing the body-cavity, two fine tortuous excretory canals appear, which terminate in minute vibrating funnels (p. 459 and Fig. 6, Pl. XXIII). The most characteristic structures are the germinal balls *Gb*, derived from the germinal cells which are seen to line the terminal part of the body-cavity (p. 200).

FIG. 2.—A young sporocyst shortly after the arrival of the miracidium in the liver of a suitable intermediate host. The ciliary coat has been lost; the organs of the body are still recognisable, though in a state of disintegration; the germinal cells *Gc* are very distinct and continually supply fresh germinal balls, while the older ones *Gb* have increased in size.

FIG. 3.—A full-grown sporocyst shown under a lesser enlargement than the two preceding Figures (note the different size of the germinal cells *Gc*). While the conditions in the posterior end are still essentially the same as before, the organs of the original miracidium are no longer discernible, and the oldest germinal balls have developed into Rediae (some transitory stages are shown, but need not be considered here).

FIG. 4.—A young free Redia under about the same enlargement as Figures 1 and 2. Note the presence of one opening at the anterior end; the germinal cells and balls in the posterior end are exactly similar to those of the miracidium.

FIG. 5.—A full-grown Redia from one of the later generations (p. 202), under the same enlargement as Figure 3. Germinal balls are still being produced as before, but now develop no longer into Rediae, but into Cercariae; some stages of this development are shown. *Op* the opening by which Rediae or Cercariae (as the case may be) escape from the mother-organisms.

FIG. 6.—A fully developed Cercaria swimming freely in the water. Note the presence, of the two openings distinctive of the adults in the body proper, and of the mobile tail at the posterior end.

FIG. 7.—An encysted Cercaria. The tail has been lost; the body proper (with one of the openings visible) lies coiled up in the cyst produced by the animal.

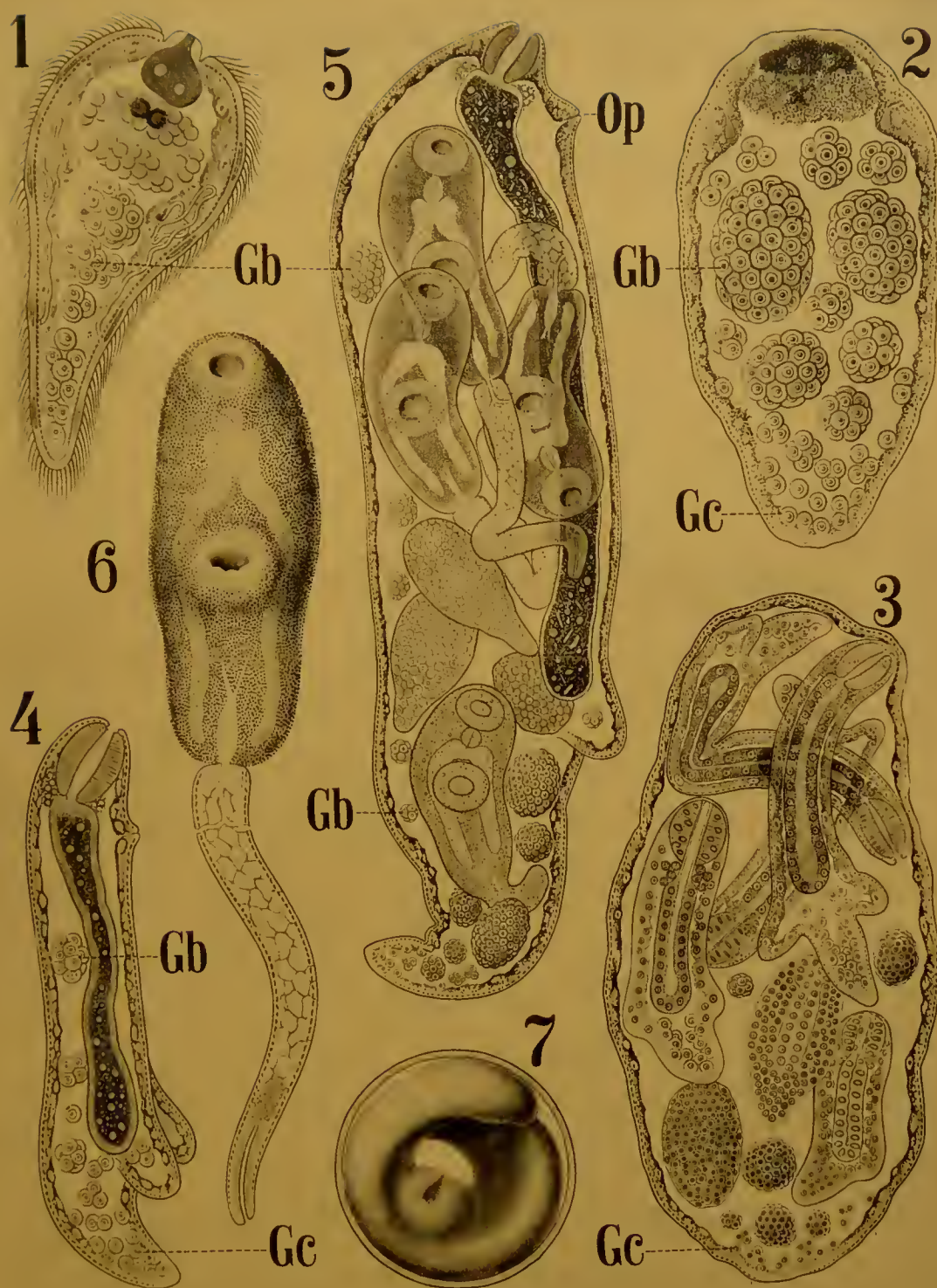


PLATE XII.

To illustrate the life-history of *Strongyloides stercoralis*, described on pages 205-207.

FIG. 1.—A full-grown parasitic and sexless specimen exhibiting the appearance of a female. *Go* the slitlike genital opening around which no copulatory structures are developed; it gives access, both anteriorly and posteriorly, to a wide tube, each containing in a row a number of eggs which proceed in their development as they approach the genital opening (the egg just below the genital opening, e.g. is seen to enclose an almost mature embryo). The tubes mentioned are the two uteri; at their ends, they each pass over into an oviduct and thence into an ovary *Ov**; the latter being a long tube filled with a continuous row of cells which become the smaller the farther away they lie from the uterus; both ovaries, if followed up further, are seen to make a bend backwards at some place, and to eventually terminate opposite each other at about the level of the genital opening. Between uterus and oviduct there is on either side a structure marked + which represents a rudimentary seminal receptacle (compare *RS*, Fig. 4). The initial portion of the body is occupied by the long and thin oesophagus *Oe* which leads into the intestine running, as a blackish strand, through the whole length of the body, to open outward by the anus *A*.

FIG. 2.—A descendant of these parasitic specimens after having escaped from the egg-shell, more highly magnified. The oesophagus *Oe*, consisting of an anterior thicker portion and a posterior onion-shaped portion, both separated from one another by a marked constriction, noticeably differs from that of the mother-individual; the genital organs are as yet in the state of the primordium *Gp*. *I* intestine, *A* anus. These larvae develop into the non-parasitic males and females shown in Figures 3 and 4.

FIG. 3.—A full-grown male. Oesophagus, intestine and anus are as before. The genital primordium has developed into normal male sexual organs, composed of a testis *T* and a vas deferens *Vd* which opens outward, together with the anus, through the ano-genital opening *A.Go*.

FIG. 4.—A full-grown female. Oesophagus *Oe*, intestine, and anus *A* are as before. The genital organs, consisting of genital opening *Go*, uteri, oviducts, and ovaries *Ov*, are structurally similar to those of the parasitic individuals, but show copulatory structures around the genital opening, and at the places marked + in Figure 1 have well-developed seminal receptacles filled in all fertilised females with numbers of small round spermatozoa (as visible in the drawing).

FIG. 5.—A fully developed filariform larva. The oesophagus *Oe*, surrounded, as in all preceding Figures, near its anterior end by the nervous system *Nr*, presents the shape characteristic of the parasitic individuals (Fig. 1); the genital organs are still in the state of the primordium *Gp*.

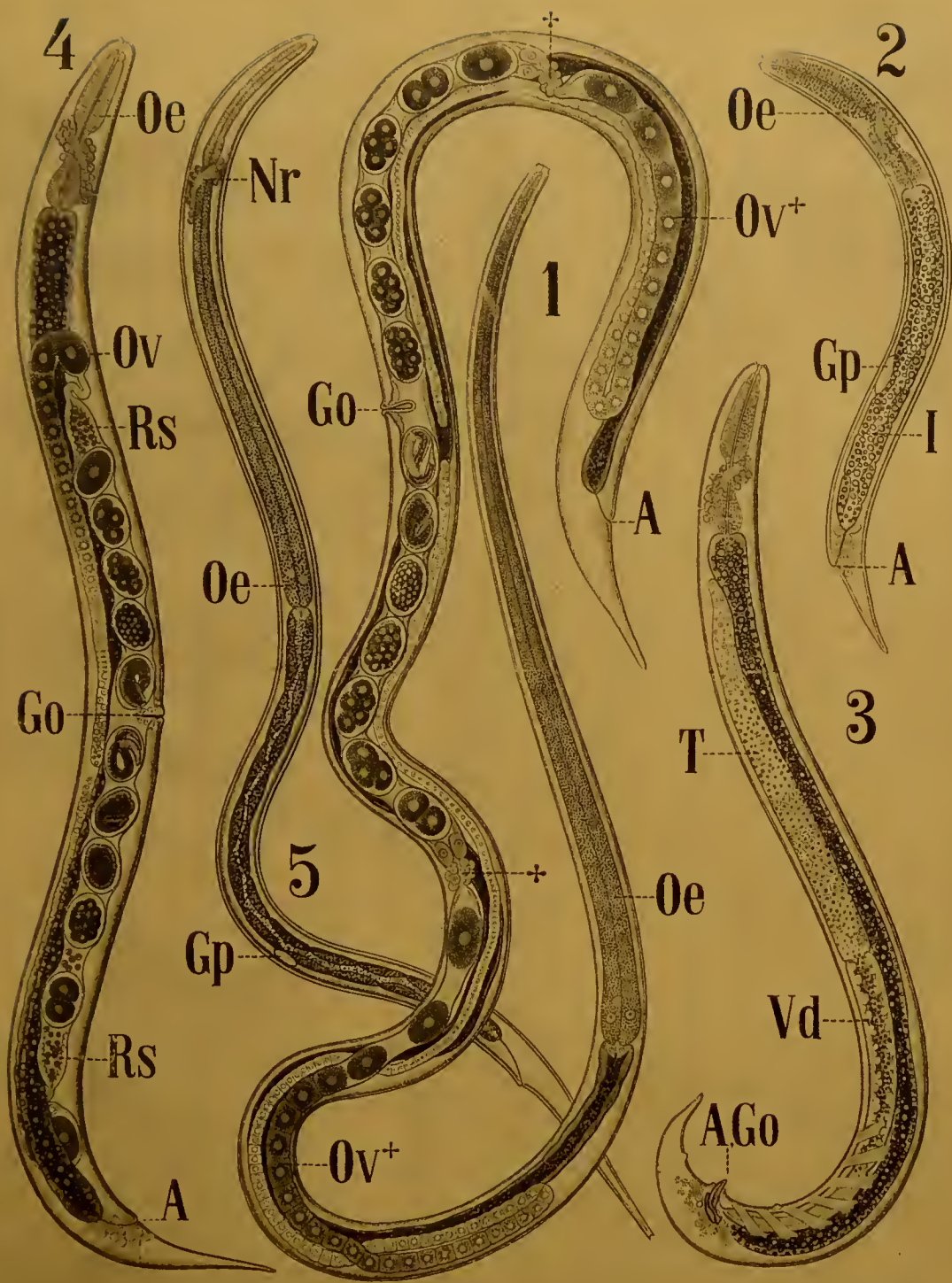


PLATE XIII.

To illustrate the structure, the life-history, and certain differential characters of the mosquitoes, described on pages 209-216.

FIG. 1.—A female *Culex*,

FIG. 2.—A female *Anopheles*, both settled on a perpendicular support, to show the general structure of their bodies (p. 209) and the differences in their attitude during life (p. 215).

FIGS. 3-5 —Three detached heads seen from the dorsal aspect, to show the sexual and generic distinctions observable in them; in all three *a* designates the antennae, *p* the palpi.

FIG. 3.—Head of a male *Culex* with long palpi and feathery antennae (pp. 209, 216).

FIG. 4 —Head of a female *Culex* with thin, filiform antennae and quite short palpi (pp. 209, 216).

FIG. 5.—Head of a female *Anopheles* with long antennae and long palpi. As to the different manner in which the antennae are carried during life see page 216 and Figures 1 and 2.

FIG. 6.—Eggs of *Culex*,

FIG. 7.—Eggs of *Anopheles*, to illustrate the generic differences mentioned on page 214f.

FIG. 8.—A larva of *Culex*,

FIG. 9.—A larva of *Anopheles* in the characteristic position they assume in the water when at rest (p. 215). Both additionally exhibit the general structure of the mosquito-larvae, viz. a small roundish head with mouth-parts and sense-organs, a somewhat thicker thorax, and an abdomen composed of nine segments adorned with tufts of bristles and hairs, but without special locomotory organs. On the dorsal surface of the last segment but one, there are the breathing-tubes, long in *Culex* (Fig. 8), short in *Anopheles* (Fig. 9), both brought into contact with the atmosphere at the surface of the water at +.

FIG. 10.—A pupa of *Culex*, to illustrate the description on page 213. + the breathing-tubes, now situated on the thorax.

FIG. 11.—Diagrammatic cross-section through the proboscis of a female *Culex*. The explanation of this diagram is given on page 210.

FIG. 12.—Diagrammatic longitudinal section through proboscis, head, and forepart of the thorax, of a female *Culex*. The tip of the proboscis has been cut off; in the remaining portion we see, above, the wider canal *i* passing over into the digestive tract, the initial parts of which are visible in the thorax; below, there is the narrower canal *s* which bifurcates in the head and in the thorax communicates with the salivary glands (only those of one side being drawn).

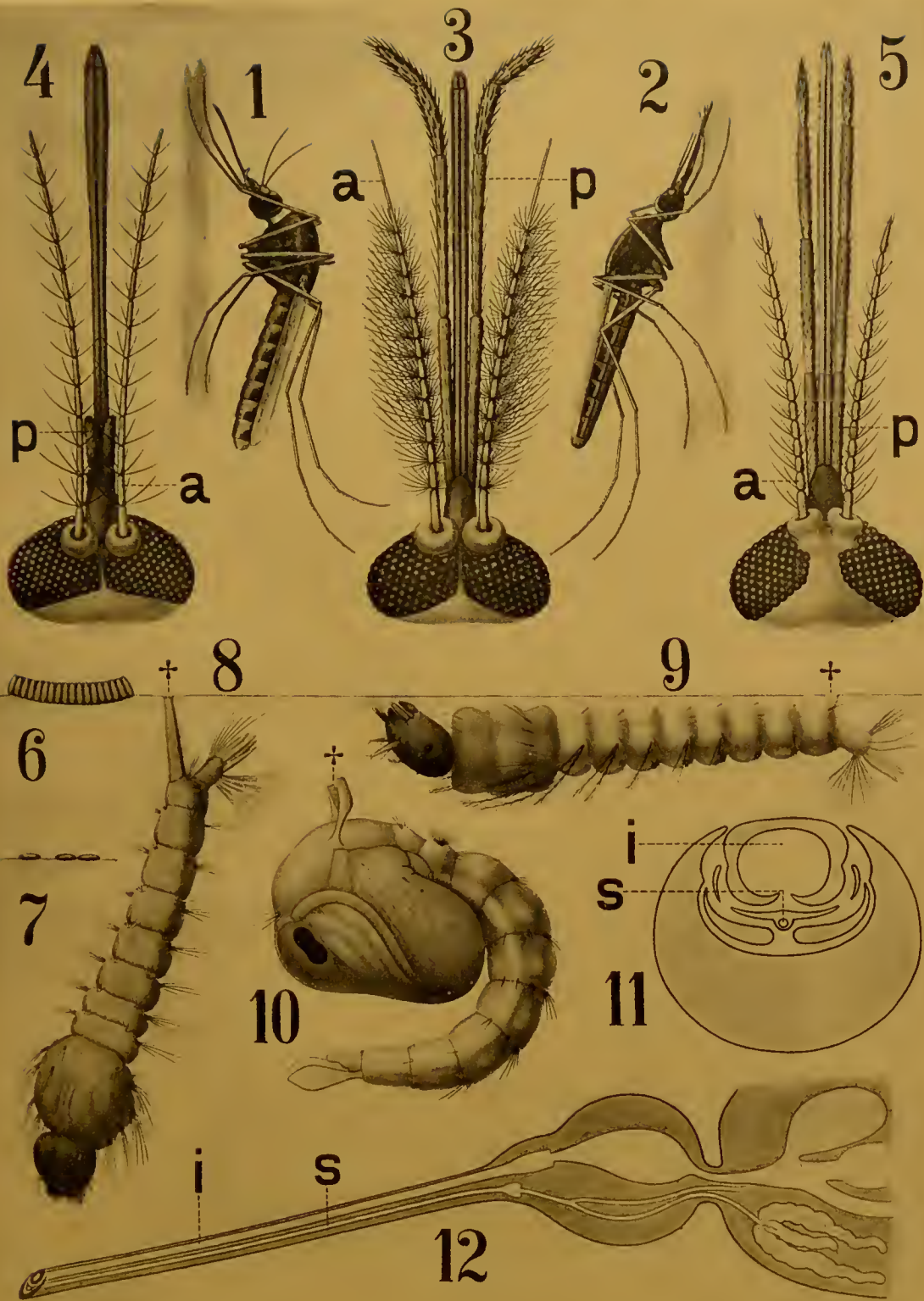


PLATE XIV.

To illustrate the structure and life-history of *Spirogyra*, described on pages 240-250.

FIG. 1.—A normal and living individual, highly magnified. The cell is surrounded on all sides by the sharply marked cellulose-wall. Beneath this, but in close contact with it, we see a thin granular layer, *pU*, the primordial utricle; near the middle of the cell, fine strands are starting from it which unite in the central mass containing the nucleus *N* (part of which is covered by a chromatophore). The specimen depicted has three chromatophores *Cr* of the characteristic shape and arrangement; each at fairly regular intervals encloses the pyrenoids *Py*.

FIG. 2.—A cell, the chromatophores of which have been omitted, in the plasmolysed condition (p. 245). Primordial utricle *pU*, central protoplasmic mass with nucleus *N*, and enclosed cell sap *CS* are clearly visible; between primordial utricle and cell-wall there is the wide space produced by the shrinking of the former.

FIG. 3.—Middle-portion of a *Spirogyra*-cell in optical longitudinal section, to illustrate the process of division (p. 246). The nucleus *N* is completely divided into two, while the surrounding protoplasmic mass, though divided also, yet shows a number of fine strands which still connect the two halves. The circular thickening of the primordial utricle appears in the diagram as two elevations *pU** (one above, one below), within which the new partition-wall is seen in the way of formation. *Cr* the optical cross-sections of the chromatophores.

FIGS. 4-7.—The copulation of *Spirogyra*. Be it understood that the four stages which in the picture appear one beside the other in the same thread are in reality consecutive phases of the process.

FIG. 4.—Two cells having formed the bulgings towards each other. The contents are as yet unchanged.

FIG. 5.—Two cells, the bulgings of which have met. The content of the lower cell is still unchanged, while that of the upper has contracted, its chromatophores being seen in commencing disintegration.

FIG. 6.—Two cells which have entered into open communication with one another by dissolution of the wall at the place of contact of their bulgings. The content of the lower cell is now also contracting; that of the upper cell, completely contracted, is passing over into the lower cell through the open communication.

FIG. 7.—The contents of both cells have fused into the zygote, the upper cell being now empty.

FIG. 8.—Two threads after completion of the copulatory process, little magnified. They present the characteristic ladder-like appearance; the cells of the upper thread, with two exceptions, are now empty, while those of the lower thread, with one exception, contain the spores, formed by the zygotes surrounding themselves with a cellulose-wall of their own. The exceptions mentioned are "bachelor-individuals" which, though desirous of copulating (as shown by the bulgings they produced), yet did not find a mate on the opposite side (p. 247).

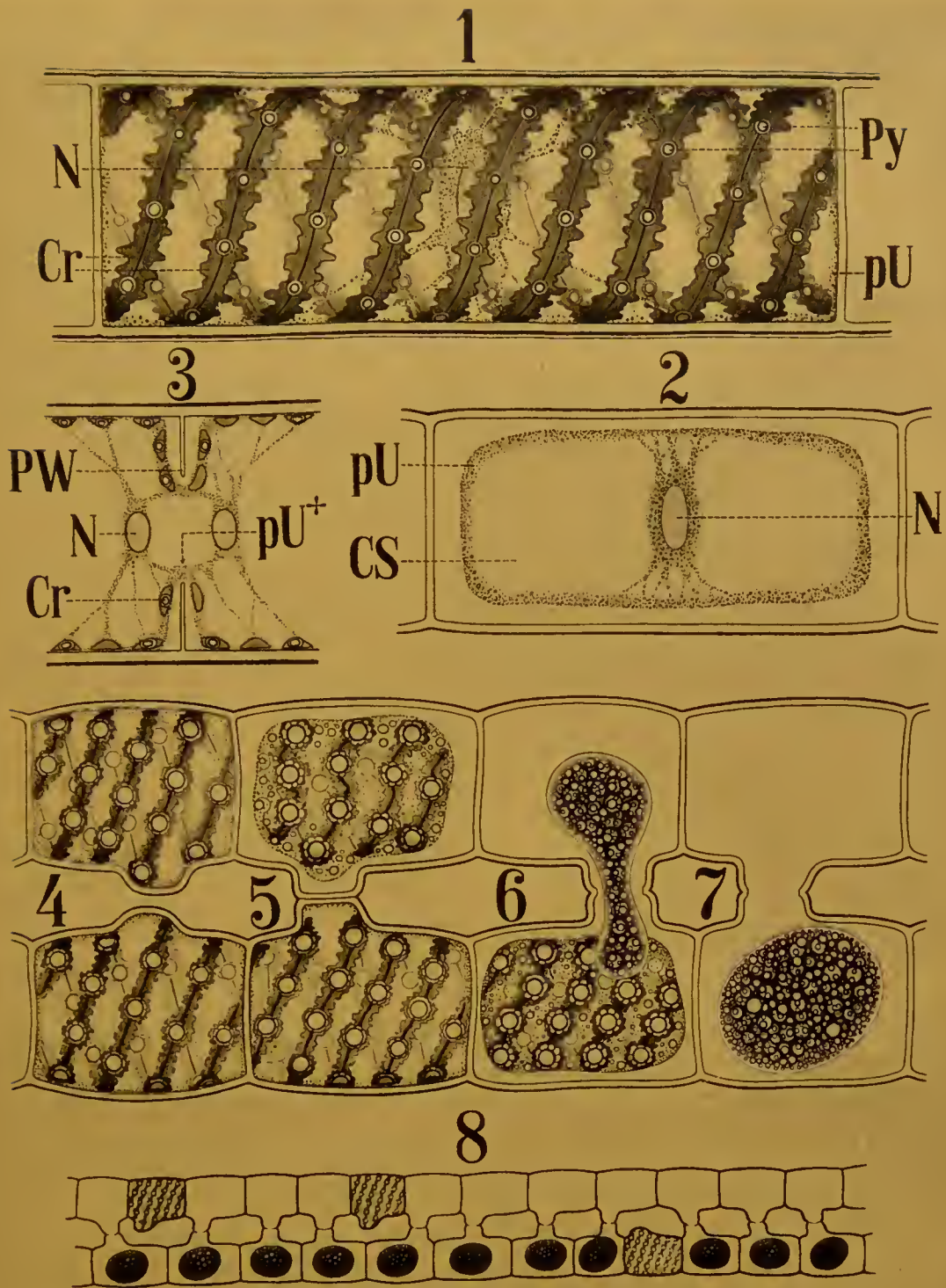


PLATE XV.

FIGS. 1-3.—To illustrate the description of *Pleurococcus*, page 251f.

FIG. 1.—A living ordinary *Pleurococcus*-cell, with cellulose-wall and protoplasmic body, the latter enclosing a small vacuole and an irregularly shaped chromatophore; the nucleus is not visible.

FIG. 2.—A small group of *Pleurococcus*-cells arisen through multiplication by division. Beginning from the bottom we see :—an ordinary cell; one in which the content is divided, while the original wall still encloses both halves; two daughter-individuals the separation of which has just been completed by the division of the wall; two similar specimens which are dropping off from the others.

FIG. 3.—One of the large individuals the content of which has broken up into sixteen daughter-cells.

FIG. 4.—Specimen of the Alga *Chlorella* (pp. 255, 415, 419); it resembles *Pleurococcus* in general appearance, but has a chromatophore of somewhat different shape and provided with a pyrenoid.

FIG. 5.—Diagram of a zoospore (which does not however belong to *Pleurococcus* in particular). The body, surrounded by a delicate cellulose-membrane, and bearing at its anterior end two flagella, encloses in the protoplasm the nucleus *N*, the chromatophore *Cr* with a pyrenoid, two small vacuoles, and a small pigment-grain of unknown nature.

FIG. 6.—Two similar zoospores copulating (p. 253).

FIGS. 7-10.—To illustrate the structure and life-history of *Volvox*, described on pages 255-257.

FIG. 7.—Diagrammatic view of a half-mature colony. The sexual cells (or individuals) have become differentiated from the ordinary vegetative individuals (*Sp* male individuals or spermatozoa, *E* female individuals or egg-cells), but are not yet fully developed.

FIG. 8.—Optical section through a vegetative individual of the colony. Within the mucous envelope (representing the wall of the sphere) we see the protoplasmic body proper, communicating to the right and to the left with the adjoining individuals, and enclosing a chromatophore and several vacuoles, while the nucleus is not visible. Of the two flagella only the basal portions have been drawn.

FIG. 9.—A male individual at the end of its development. The small cells visible in *Sp*, Figure 7, have increased in number by further divisions, and have eventually assumed the shape and regular arrangement visible in the drawing.

FIG. 10.—One of these spermatozoa more highly magnified. It exhibits the thin cellulose-membrane and, at the base of the anterior thinner part of the body, two flagella, while inside, the nucleus *N*, the chromatophore *Cr*, and a small vacuole are seen.

FIG. 11.—The copulation, or fertilisation, in *Volvox*. A number of microgametes, or spermatozoa, have entered the mucous envelope of the macrogamete, or egg-cell, in order to fuse with it.

FIG. 12.—Diagram of a specimen of *Botrydium* (p. 266). It shows, as a consequence of the working of the principles of division of labour and functional adaptation, a division of the unicellular body into two distinct portions; the aboveground vesicular portion, coloured green by numerous small chromatophores, corresponding to the shoot the underground, ramified and colourless portion to the root of the higher plants.

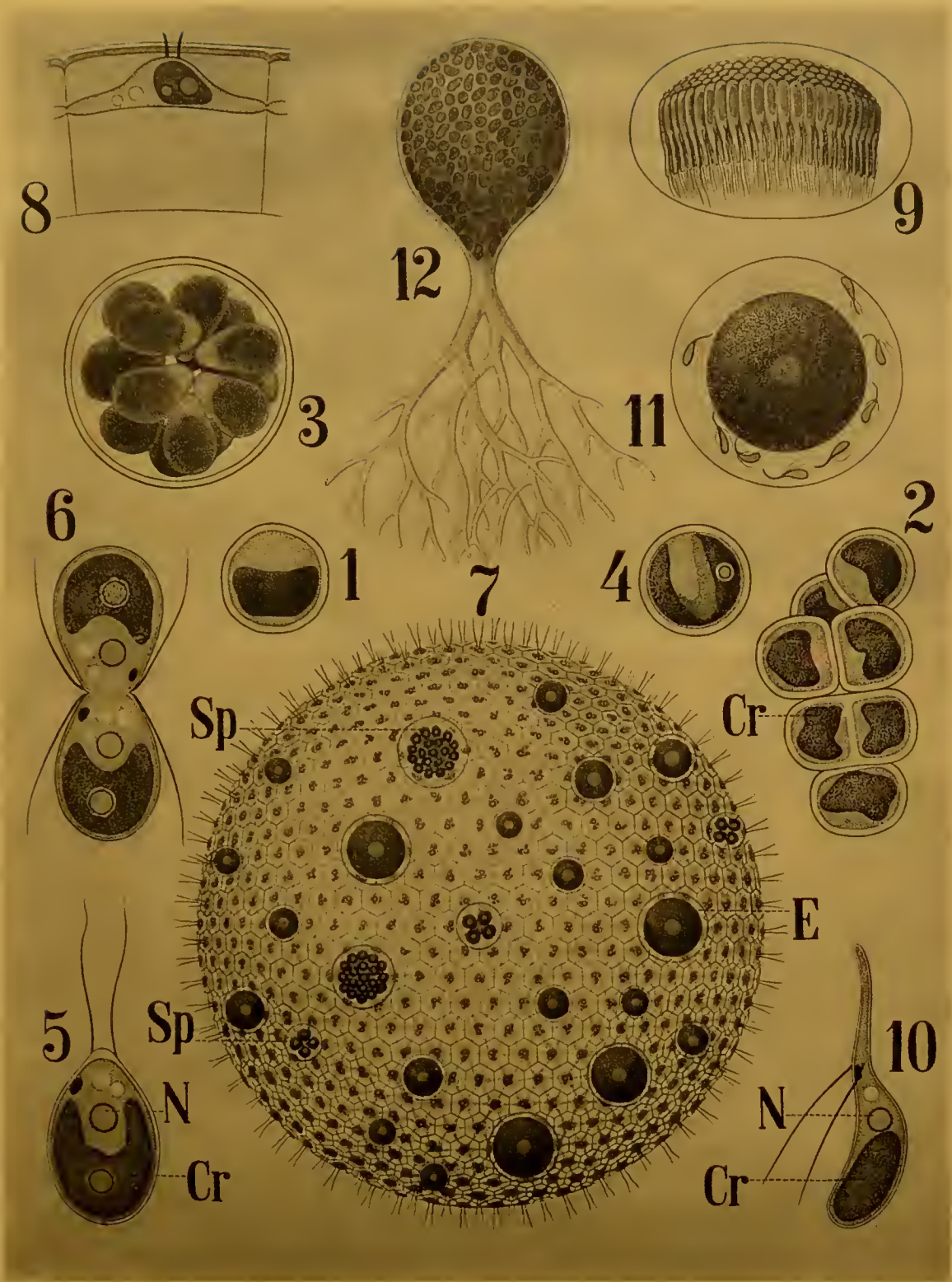


PLATE XVI.

FIG. 1.—A small colony of the yeast-fungus (p. 298) arisen by repeated, as yet incomplete divisions of a mother-cell (the lowermost in the figure). The division takes place by budding, the daughter-individuals making their first appearance in the shape of small bud- or knob-like outgrowths from the mother-individuals. The cells exhibit, within their cellulose-membrane, the protoplasmic body proper with the nucleus (shown dark in the drawing) and one large or several smaller vacuoles, but are destitute of chromatophores (p. 297).

FIGS. 2-14.—To illustrate the description of the Bacteria (pp. 304-308).

FIG. 2.—Sketch to show the aggregation of individuals characteristic of *Streptococcus*.

FIG. 3.—The same of *Diplococcus*.

FIG. 4.—The same of *Staphylococcus*.

FIG. 5.—The *Bacillus* of typhoid fever as an example of peritrichous Bacteria.

FIG. 6.—An undetermined *Bacillus* as an example of lophotrichous Bacteria.

FIG. 7.—The cholera-*Vibrio* as an example of monotrichous Bacteria.

FIG. 8.—*Spirillum undula*, alive (to the left), and preserved and stained (to the right); the latter specimen shows the flagella and a commencing division.

FIG. 9.—A form of *Spirochaete* from foul water, alive (to the left), and preserved and stained (to the right).

FIG. 10.—A colony of Bacteria showing the characteristics of *Cladothrix*.

FIG. 11.—Similar colony of *Streptothrix*; both threads being stained, but one composed of individuals in their ordinary condition, the other of individuals transformed into spores.

FIG. 12.—Portion of a zoogloea.

FIG. 13.—Diagram to show the characteristics of endospores; group to the left in a fresh, to the right in a stained condition.

FIG. 14.—Diagram to show the characteristics of telospores.

FIG. 15.—Portions of three threads of the fungus *Trichophyton tonsurans* (p. 295): one in the ordinary condition, the two others in the way of breaking up into small round portions, the spores.



PLATE XVII.

FIGS. 1-10.—Diagrams to illustrate various peculiarities of vegetable cells.

FIG. 1.—Cell-walls with ordinary pits (p. 328f). The diagram shows two walls seen from the surface and presenting the pits as small round holes, while a third, running towards the observer, is seen from its (cut) edge and presents the pits in longitudinal section, thus exhibiting the thin closing membrane in the middle of each.

FIG. 2.—Drawing to explain the structure of the bordered pits (p. 329); *a* showing these in surface-view, *b* in longitudinal section. While the ordinary pits (Fig. 1) are of equal width in the middle and at both ends, the bordered pits are narrower at the latter than they are in the middle. *cM* the closing membranes, here lying against one opening of the pits.

FIG. 3.—A group of stone-cells in optical section. The thick walls show a concentric striation due to growth by apposition: the pits appear as ramified thin canals (pp. 328, 347).

FIG. 4.—Diagram of a sclerenchymatous cell, and

FIG. 5.—Of a libriform cell; both showing as their most outstanding characters an elongated shape, a comparatively thick wall with very small, cleft-like pits (p. 346).

FIG. 6.—Sketches of sieve-tubes, showing the connection of two consecutive cells, i.e. the places where the sieve-plates are found. In *a*, taken from *Helianthus annuus*, عباد الشمس, the sieve-plate, seen in optical section, stands at about right angles to the axis of the tubes; the (slightly shrunken) protoplasmic contents of the latter are indicated. *b* and *c* are sieve-tubes of the vine (*Vitis vinifera*), in which the sieve-plates are very obliquely placed and perforated by holes collected in groups; *b* showing such a sieve-plate in optical section, *c* in surface-view (p. 339).

FIGS. 7-10.—Various forms of vascular cells distinguished by the specific markings of their walls (pp. 329f and 340).

FIG. 7.—A cell with annular markings; of the three first rings from the bottom, only the farther half has been represented, in order to show that the rings are indeed local thickenings of the otherwise thin cell-wall.

FIG. 8.—A cell with spiral markings of the wall.

FIG. 9.—A cell with reticulate markings, halved longitudinally; the nearer half having been removed, the farther half being seen from its inside.

FIG. 10.—Lower end of a cell with scalariform markings. The oval opening at the bottom establishes the communication with the adjoining cell.

FIG. 11.—Sketches of grains of reserve-starch, showing the three chief varieties which exist (p. 334). *a* simple grain, *b* half-compound grain (both of the potato, *Solanum tuberosum*), *c* compound grain (of rice, *Oryza sativa*, أرز, made up of a comparatively large number of constituent grains).

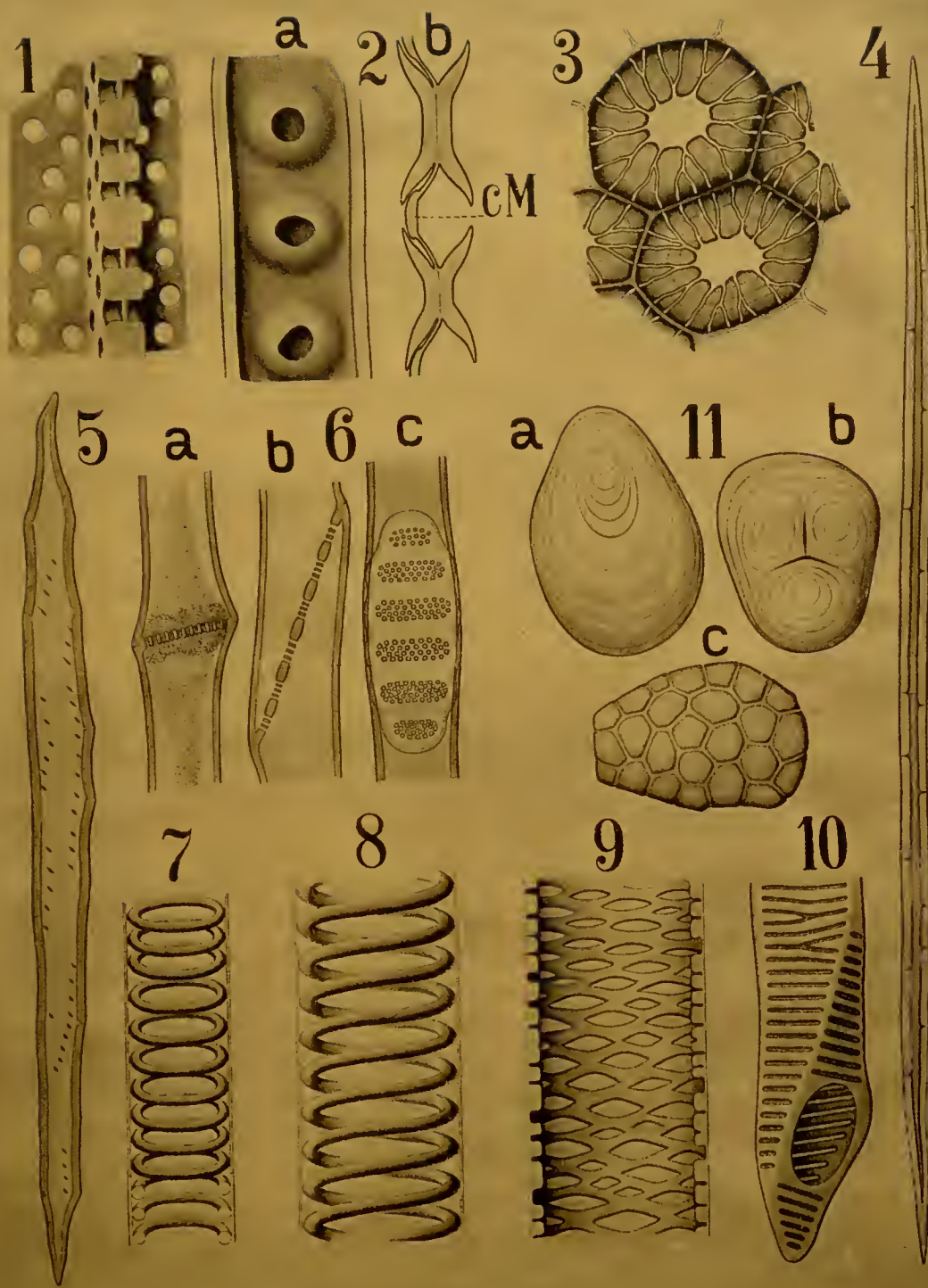


PLATE XVIII.

To illustrate the structure of vegetable tissues and organs.

FIG. 1.—A group of collenchymatous cells (p. 346) in cross-section. The thickenings of the wall are restricted to the angles.

FIG. 2.—A group of sclerenchymatous cells in cross-section (p. 346). The cell-walls are equally thickened throughout and perforated only by very small pits. The small cross-sections belong to cells cut near their (tapering) ends.

FIG. 3.—Part of a cross-section through a leaf (of *Passiflora* شريك الفاكه); the section is taken near the tip, the thickening to the left corresponds to the median vein (or nerve). We see the (upper and lower) surfaces occupied by the epidermis *Ep*, the cells of which under these circumstances present their regularly rectangular appearance (p. 336); one of the upper side has grown out into the (unicellular) hair *H* (p. 337); on the lower side two stomata *Sto* have been cut through. The space between the two epidermal layers is occupied by the assimilation-tissue (p. 347) clearly separated into the palisade-parenchyma *Pa* and the spongy parenchyma *Sp*; the chromatophores of all cells are numerous and small (p. 243). Everywhere between the parenchyma-cells we see the intercellular spaces which communicate with the outer world by the stomata (pp. 338 and 365). In the vein of the leaf we perceive a vascular bundle *VB* as yet composed of only a few vessels (p. 366); the noticeable thickening of the cell-walls in the lower (or under-) half of the vein is indicative of its mechanical function (pp. 364, 366).

FIG. 4.—Stoma (of a cabbage-leaf), more highly magnified and seen from its surface (p. 365). *GC* the two guard-cells with their numerous small chromatophores; *Ep* the surrounding normal epidermis-cells, presenting in this condition their irregularly wavy outlines (p. 336).

FIG. 5.—A stoma from the section Figure 3 more highly enlarged. It shows the two guard-cells, each composed of a fairly thick cellulose-wall and a protoplasm enclosing, near its surface, a number of chromatophores *Cr* and, in the middle, a small vacuole; the nuclei are not visible. The higher enlargement of the section also brings the cuticle *Cu* (pp. 336, 364) more distinctly into evidence.

FIG. 6.—Terminal portion of a cotton-fibre (p. 337). It represents a unicellular epidermal hair and originates as an outgrowth of a cell after the fashion of *H* in Figure 3; in its present condition it is collapsed and twisted owing to dessiccation.

FIG. 7.—Diagrammatic view of a simple dicotyledonous flower halved longitudinally, the lower half being seen from its cut surface (see pp. 367–369). *FSt* the flower-stalk; *Ca* the calyx, composed of the sepals *Se* (the lower portions of which are coalesced into one; *Pe* the petals; *St* the stamens bearing at their tops the anthers *An*; the pistil, consisting of the stigma *Sti*, the style *Sty*, and the ovary (*E*), is single; the ovary, as it is located (in the case depicted, but not always; see p. 369) within the calyx, causes the swollen aspect of this latter.

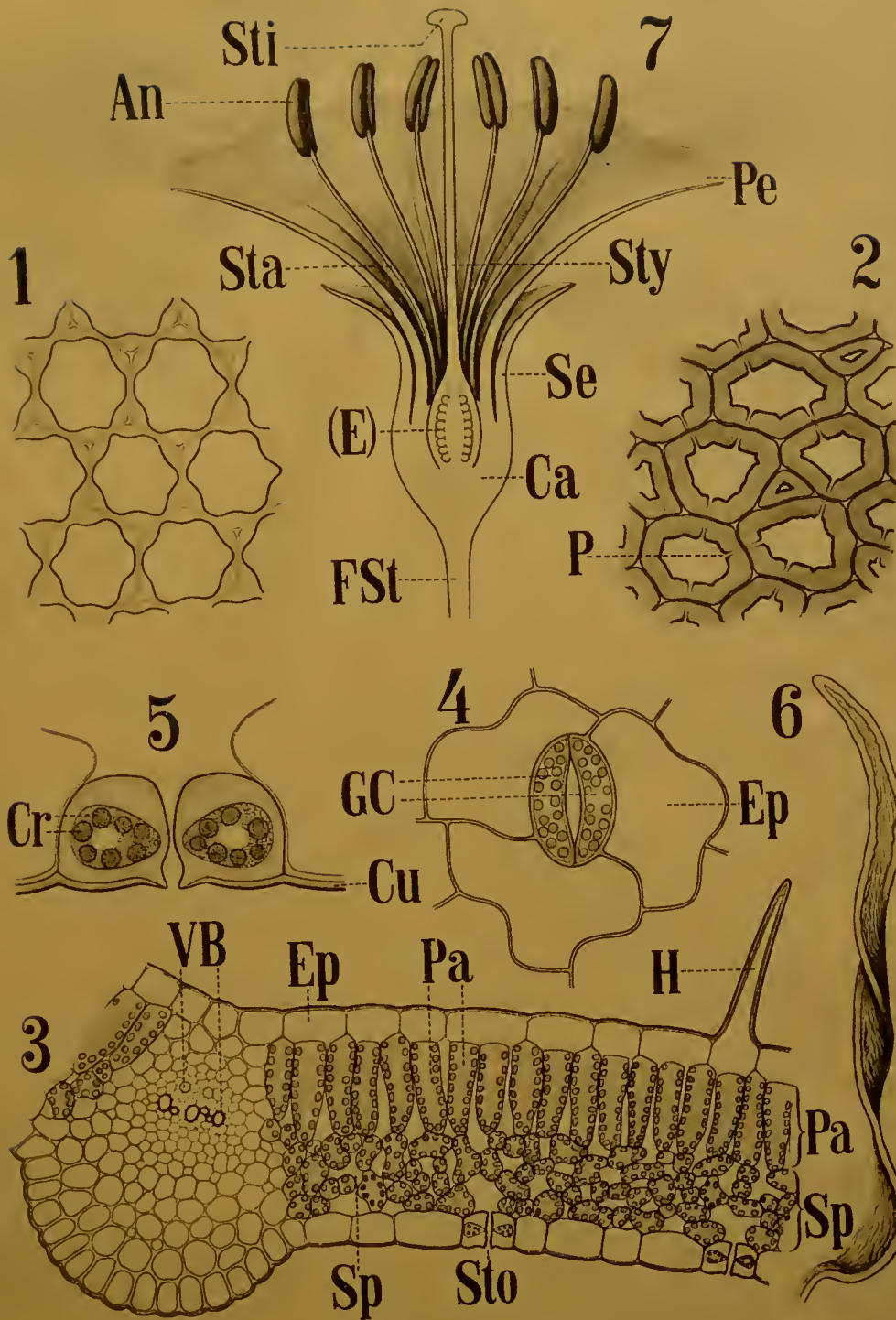


PLATE XIX.

To illustrate the structure of vegetable tissues and organs (continuation of Pl. XVIII).

FIG. 1.—Cross-section through a stem (of *Passiflora* شجر الغلك), to illustrate the description on pages 361–362. Figure 1a, a whole cross-section, feebly enlarged, to show the general distribution of the constituent parts. The vascular bundles *VB*, each composed of a xylem-portion *x* and a phloem-portion *p*, are all arranged in a ring below the surface; the cambium, separating xylem and phloem and forming a continuous layer *Ca*, appears in the drawing as a white band crossing the vascular bundles. Figure 1b, a portion of the above section more highly magnified. We here see on the surface the epidermis *Ep*, below this several layers of sclerenchymatous cells with considerably thickened walls, and below these the vascular bundles *VB* with the continuous cambium-layer *Ca* separating them into two portions; in the xylem-portions the tracheae *V* appear as farly wide spaces, while in the phloem-portions the sieve-tubes, owing to their insignificant diameter, could not be distinctly marked. *Gr* ground-tissue composed of loosely grouped, large, thin-walled cells (p. 341).

FIG. 2.—Cross-section of a vascular bundle (of *Helianthus* عباد الشمس), more highly magnified (compare p. 359f). *Scl* (above) sclerenchymatous cells of the phloem-portion; *ST* sieve-tubes (in some of which the sieve-plates are recognisable); *Ca* cambium; *V* vessels of the xylem-portion united into a whole by the libriform cells *Scl* (below). The whole bundle is surrounded by cells of the ground-tissue.

FIG. 3.—Cross-section through a young root (of *Vicia faba*, فول) to illustrate description on pages 359, 360. Figure 3a an entire cross-section, feebly enlarged, and showing cortex and central cylinder; the latter composed of a phloem- and a xylem-portion, between which the cambium appears as a white band (as it did in Fig. 1a). Figure 3b a portion of the above section more highly enlarged. *Co* cortex, composed of the epidermis *Ep* and a thick layer of ground-tissue-cells *Gr*. *CC* central cylinder; the xylem-portions *V* of the vascular bundles are seen to lie opposite the intervals between every two phloem-portions *Scl*; the cambium being by this arrangement forced to assume a wavy course.

FIG. 4.—Median longitudinal section through the tip of a growing root (of *Vicia faba*, فول), to illustrate the description on page 349f. The area where the root-hairs begin to grow out from the epidermal cells (p. 356) lies still some distance back of the part depicted; the root-hairs do not therefore appear in the drawing. *CG* the centre of growth; *Ep* the epidermis as yet hardly distinguishable from the neighbouring cellular layers; *RC* the root-cap, some superficially situated cells of which are seen in the act of detaching themselves.

FIG. 5.—A cell from the neighbourhood of the centre of growth in a growing shoot, more highly magnified, to show the average appearance of a young vegetable cell (compare p. 349). There is the cellulose-wall, as yet very thin and delicate; the granular protoplasm is still destitute of vacuoles, but encloses a number of young chromatophores *Cr* (p. 332) and a comparatively large nucleus *N* with chromatic network and nucleolus *n*.

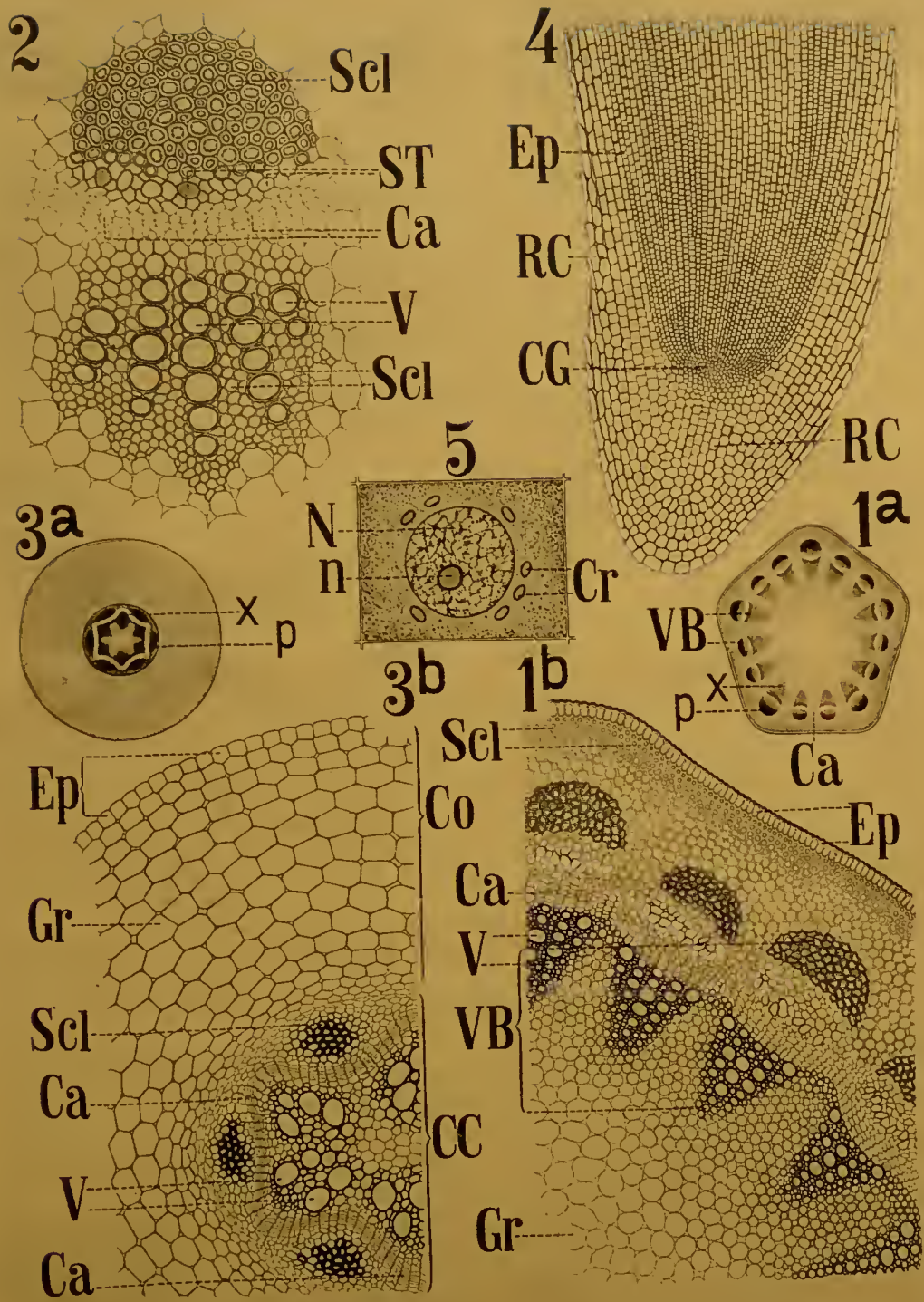


PLATE XX.

Diagrams to illustrate certain phenomena in the early development of the Metazoa.

FIGS. 1-4.—Four stages in the cleavage of the frog's egg (pp. 410 and 428).

FIG. 1.—The egg-cell has divided into two (Two-cell-stage).

FIG. 2.—A second division has taken place at right angles to the plane of the first division; both planes passing through the axis of the body of the later embryo (Four-cell-stage).

FIG. 3.—A third division has taken place (Eight-cell-stage). As it is transversal, i.e. takes place at right angles to the axis, it is the first to mark off the (smaller) animal cells from the (larger) vegetative cells (p. 428).

FIG. 4.—An embryo in the morula-stage (p. 410). Although the embryonic (or cleavage-) cells have increased in number, and commensurately decreased in size, the difference between animal and vegetative cells is still clearly recognisable.

FIGS. 5-7.—Three stages in the gastrula-formation by invagination (pp. 411 and 431).

FIG. 5.—A blastula halved longitudinally, the depicted half seen from its inside. The wall consists of one layer of cells, the animal cells *A* being smaller and more numerous than the vegetative cells *V*. *BC* the blastocoel or segmentation-cavity.

FIG. 6.—The posterior wall of the blastula, composed of the vegetative cells, has become flattened and is now beginning to bend inward.

FIG. 7.—The bending inward has advanced so far that the (originally) posterior wall of the blastula lies closely against the inside of the (originally) anterior wall, a double-layered sac being thus formed, in which the former portion of the wall represents the entoblast *En*, the latter the ectoblast *Ec*. The sac, as before, encloses a cavity, which now, however, at the posterior end communicates with the outer world by the blastophore *BP*, and is the archenteron *AE*.

FIGS. 8-13.—Diagrams to illustrate the variations in the cleavage-process described on pages 429-430.

FIGS. 8-11.—Some stages of the discoidal cleavage (p. 429). In

FIG. 8, we see the germinal disc (with a part of the surrounding yolk *Y*) from its surface, four areas being marked off from one another by clefts as the result of the two first divisions of the nucleus.

FIG. 9.—A slightly more advanced stage in longitudinal section. It is here seen that the three vertical clefts mark off four cellular areas, each with a nucleus, but at their bases all still continuous with the yolk.

FIG. 10.—A further advanced stage seen from the surface. In the centre we now perceive a number of cellular areas which are delimited all round, while the marginal areas are delimited towards the centre, but still cohere with the unsegmented part of the germinal disc peripherally. How the central areas are finally transformed into complete cells is shown by

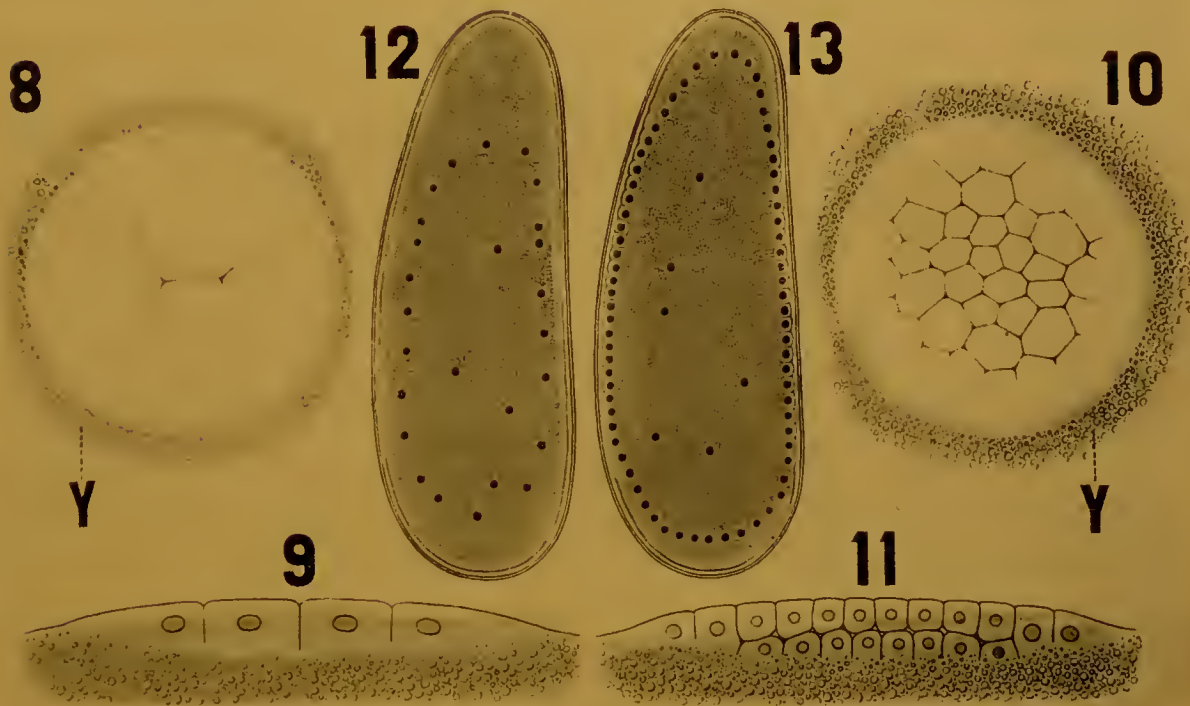
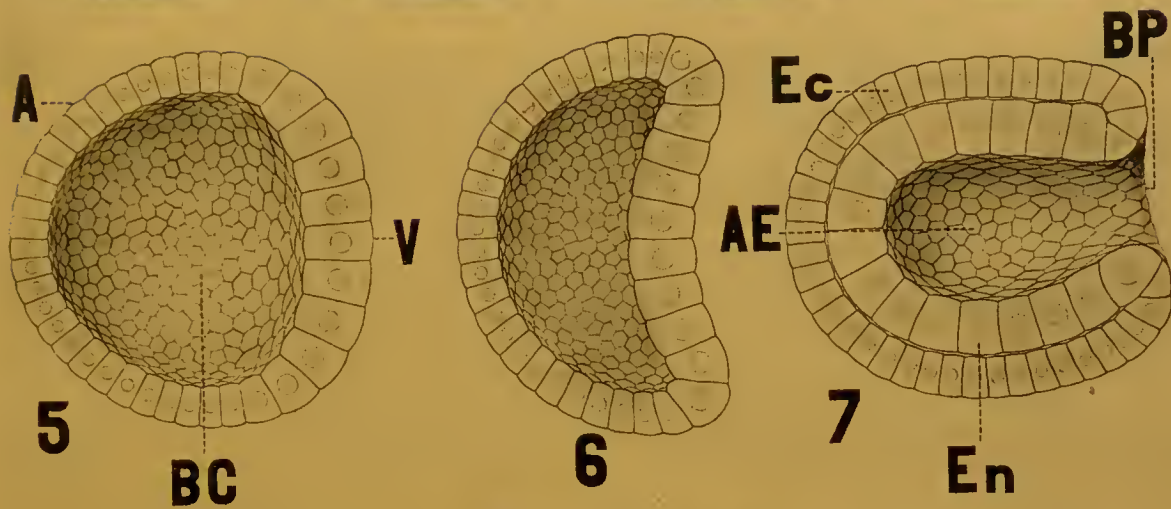


PLATE XX (*continued*).

FIG. 11, which again represents a cross-section. We here see that in the central cellular areas a division has taken place, the plane of which runs parallel to the surface of the disc; the upper portions of each area having thereby been cut off from the lower portions, and thus delimited on all sides, while the lower portions, as well as the not yet divided marginal areas, still cohere with the yolk as before (p. 429).

FIGS. 12-13.—Two stages from the superficial cleavage of the eggs of insects (p. 430). In

FIG. 12, the nuclei, derived from repeated divisions into two of the original nucleus, are still irregularly scattered through the yolk. In

FIG. 13, they have increased in number and shifted to the surface of the yolk. On both sides of the egg the process is accomplished and the blastoderm formed, while at the poles the nuclei have not yet reached their final position. Some nuclei have remained within the yolk.

PLATE XXI.

Diagrams to illustrate the structure and life-history of *Hydra* (for description see pp. 413-419).

FIG. 1.—A full-grown *Hydra* halved longitudinally, the half depicted seen from its inside. The body-wall consists throughout of two cellular layers; the small dark bodies in the outer layer are nettle-cells. The digestive cavity enclosed by the body-wall opens outward through the mouth *M*, transmits a diverticulum into each of the tentacles *Tl*, but has no posterior opening. *Ts* two testicular swellings of slightly different age; *Ov* an ovary with one amoeboid egg-cell inside; the dark dots in its protoplasm are specimens of the alga *Chlorella* (p. 415) immigrated into the egg-cell from the neighbouring entoderm-cells. *B, B* are young buds, the one to the left seen in longitudinal section, the other just looked into through its communication with the enteron. A third bud to the right has developed into an almost complete young *Hydra* with tentacles, mouth, and enteron; the latter however still communicating with the enteron of the mother-individual. All three buds show that their own body-walls are mere continuations of the body-wall of the mother-*Hydra*.

FIG. 2.—Cross-section through a *Hydra*, somewhat more highly magnified. The ectoderm *Ec*, with several nettle-cells, and the entoderm *En* are separated from each other by the supporting membrane *SM*. The small dots appearing in this latter are the cross-sections of the longitudinal muscle-fibres starting from the bases of the ectoderm-cells (p. 415).

FIG. 3.—An entoderm-cell, isolated and more highly enlarged. It shows the flagellum on its free (inner) surface and the two contractile processes starting from its base in a circular direction (p. 415). Within the body, we see a number of vacuoles pushing, as a whole, the protoplasm somewhat to one corner; in the protoplasm lie the nucleus *N* and near the base of the flagellum a number of *Chlorellae*.

FIG. 4.—Two entire *Hydrae* fixed to their support, under a low enlargement. Both specimens carry a number of buds in different stages of development. The upper individual is strongly contracted, while the lower presents about the usual appearance; to the right, a small water-crab has been caught between its tentacles which are coiling round the prey (p. 416).

FIGS. 5-8.—Some stages out of the development of *Hydra* (p. 431) in optical section.

FIG. 5.—The blastula, swimming freely in the water by the aid of the flagella which have been developed from the blastoderm-cells.

FIG. 6.—Some of the vegetative cells at the posterior end have divided; the newly formed cells begin to form a cluster which lies against the inside of the blastula-wall.

FIG. 7.—The cluster of newly formed cells has increased in size and number of constituent elements.

FIG. 8.—The cells have further increased; a fine longitudinal slit is making its appearance in their midst; by widening, and eventually breaking through the blastula-wall at the posterior end, it transforms the blastula into a gastrula.

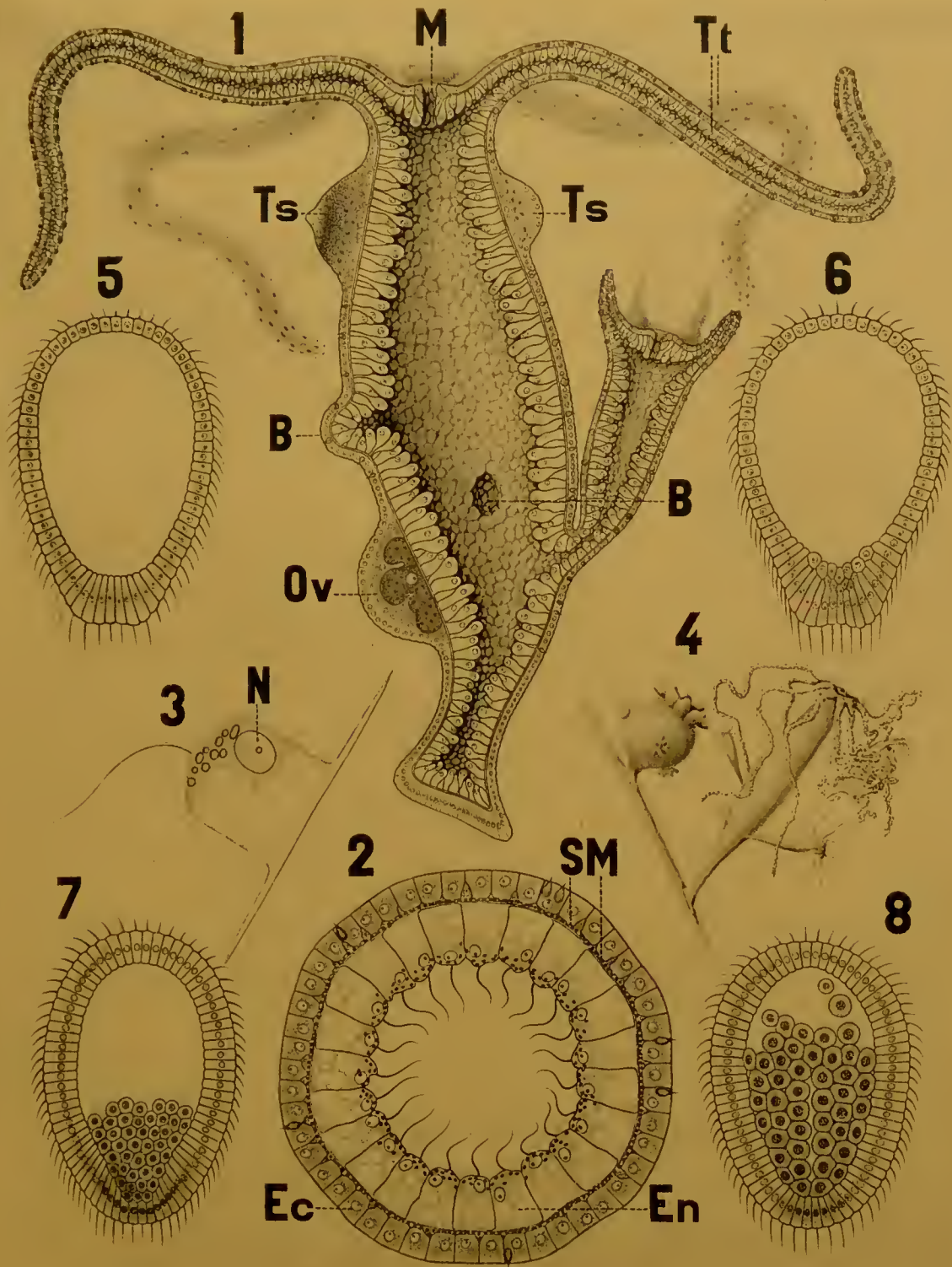


PLATE XXII.

FIGS. 1-3.—Three stages of the gastrula-formation in the frog, to illustrate the description on page 432f.

FIG. 1.—Longitudinal section through the blastula; the left side corresponding to the anterior, the right side to the posterior end of the later embryo. *A* the animal, *V* the vegetative cells, *BC* the blastocoel.

FIG. 2.—Similar section, showing an early stage of the invagination; the animal cells *A* cover an enlarged part of the circumference of the embryo, the vegetative cells have been pushed inwards and begin to line the archenteron *AE*. *BP* the blastopore; *BC* remainder of the blastocoel.

FIG. 3.—Similar section showing the gastrula fully formed. The animal cells, with the exception of a small area at the posterior end, now cover the whole embryo and represent the ectoblast *Ec*; the vegetative cells lie almost entirely within the body and, as they now line the archenteron *AE*, represent the entoblast; the original blastocoel *BC* is reduced to insignificant clefts between ectoblast and entoblast. *BP* the blastopore, from the neighbourhood of which the mesenchym-elements *Mch* (p. 438) begin to push forward into the blastocoel-clefts.

FIGS. 4-8.—Diagrams to illustrate the formation of mesoblast and coelom in the embryo of the frog.

FIG. 4.—Cross-section through the gastrula at the place, and in the direction, indicated by the arrow in Fig. 3; a description is given on page 435.

FIG. 5.—Combination of two halved cross-sections, showing, the left half-cross-section an earlier, the right half-cross-section a later stage in the development of the mesoblast *Me*; a description of the process is given on page 435f. The arrows indicate the places from which, and the direction in which, the outgrowths first arise.

FIG. 6.—Mid-dorsal portion of a cross-section through an embryo in a later stage. The two mesoblast-folds *Me*, with the coelom *Coe* between them, are, in the direction of the arrows, still in connection with the archenteric cavity. *MP* medullary plate, *Nch* notochord.

FIG. 7.—The same portion of a section through a still later stage. The two mesoblast-folds *Me* with the coelom *Coe* between them have now severed their connection with the entoblast by a closure of the openings at the points of the arrows in Figure 6. The notochord *Nch* also has become separated from the entoblast and lies as an independent body between this and the ectoblast, with the mesoblast-folds on either of its sides. The medullary plate has become transformed into the medullary groove. For details of the first development of nervous system and notochord see pages 439, 440.

FIG. 8.—Diagrammatic cross-section through an embryo with fully developed coelom. *Ec* ectoblast, *En* entoblast, *AE* archenteron, *SoM* somatic, *SpM* splanchnic mesoblast; *Coe* coelom; *Nrv* spinal chord; below it, but not specially marked, the notochord, and below this, several blood-vessels cut through. A more detailed explanation of the section is found on page 437.

FIG. 9.—Diagrammatic cross-section, to illustrate the relation between coelom and pronephros (details on p. 461). *Nrv* spinal chord; *Nch* notochord; *BlV* descending aorta; *My* mesentery; *PNC* pronephric canal; *NSt* nephrostome; *Gl* glomerulus.

FIG. 10.—Similar cross-section to show the relation between coelom and mesonephros (details on p. 463). *Nrv*, *Nch*, *BlV*, *My*, *Gl*, and *NSt* as before; *MNC* mesonephric canal.

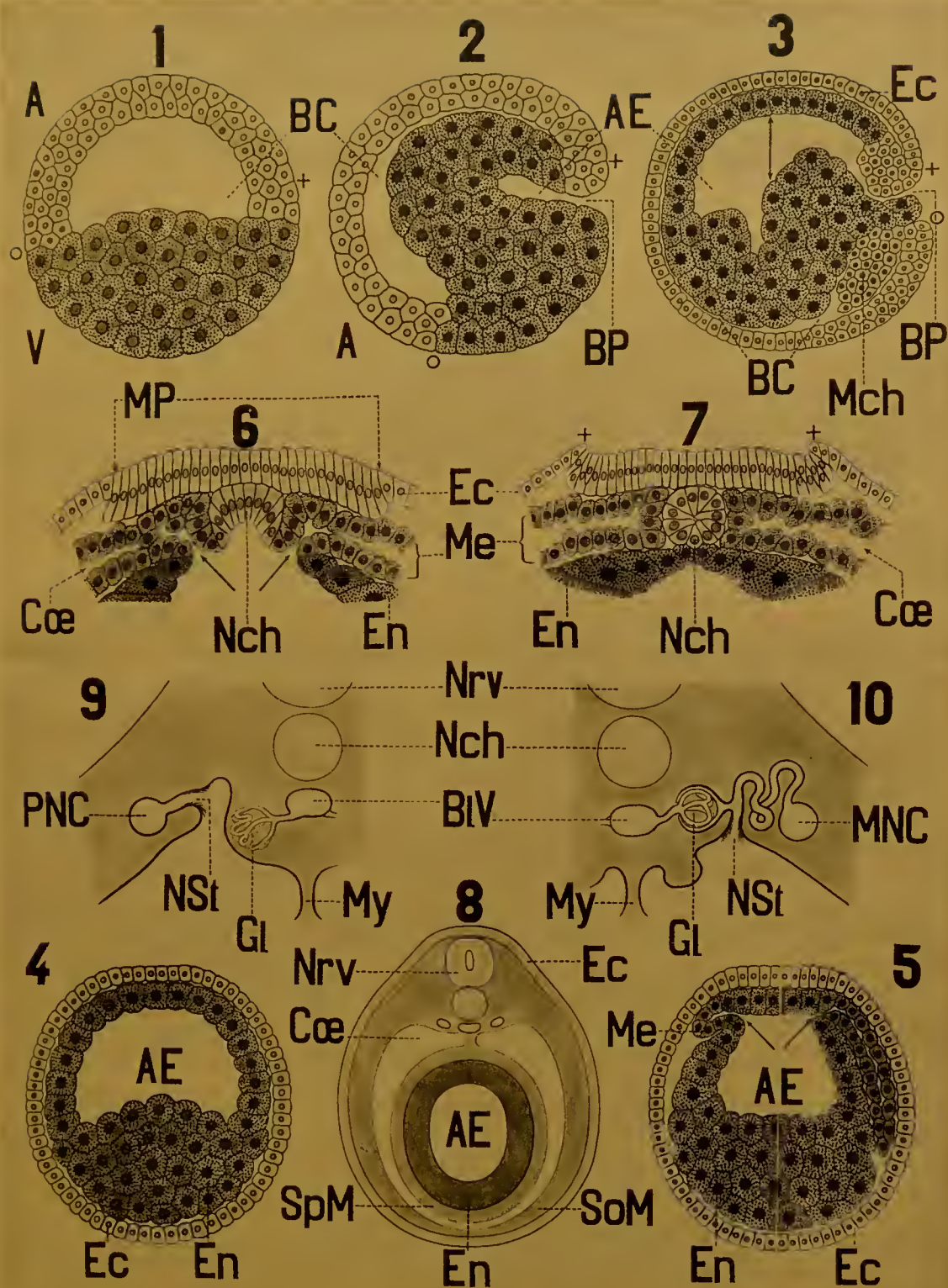


PLATE XXIII.

FIGS. 1-5.—To illustrate the discussion of the relations between circulatory and respiratory systems of the Metazoa (pp. 445-458).

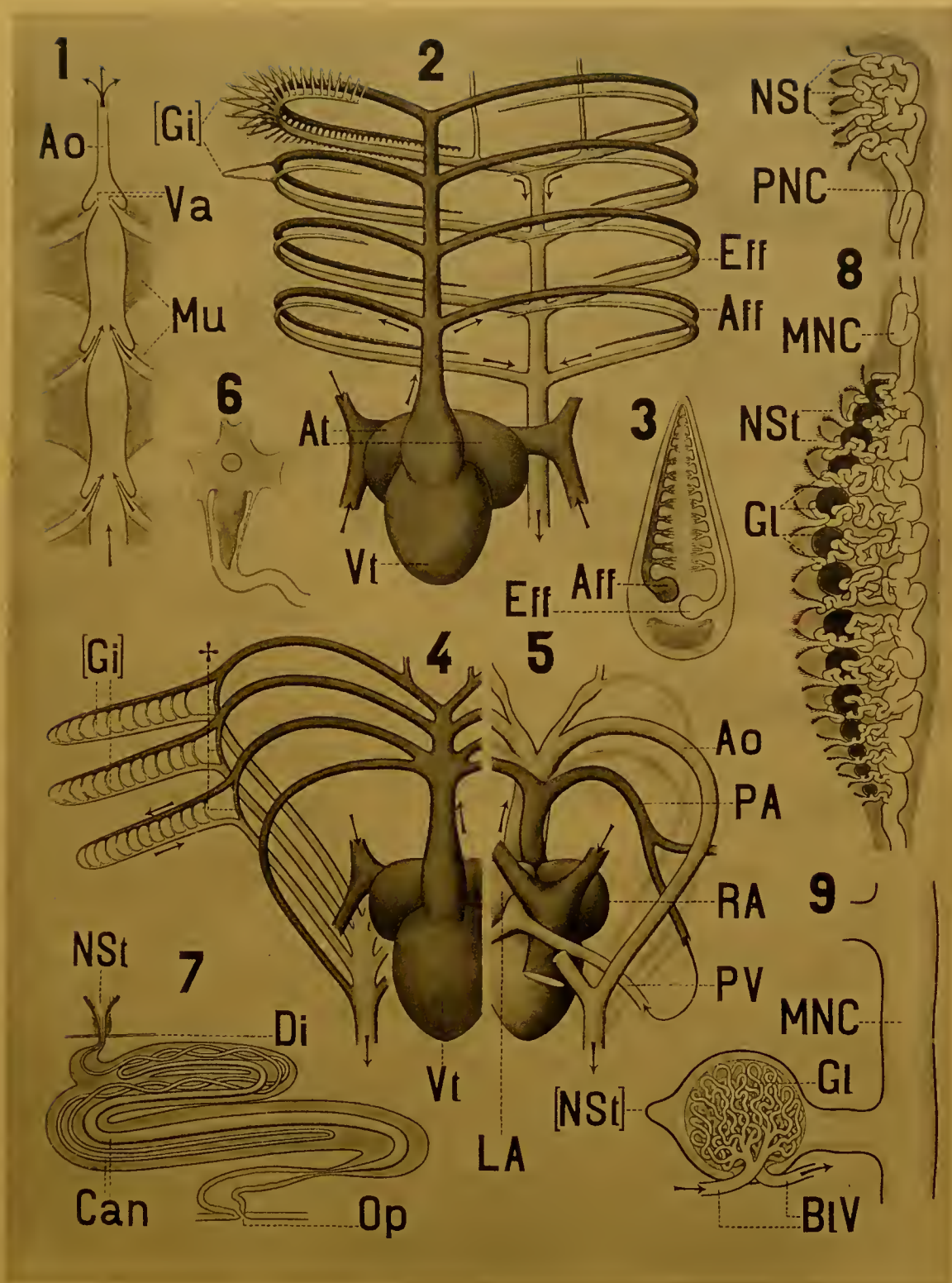
FIG. 1.—Anterior portion of the heart of an insect. *Va* lateral valves, *Ao* the short anterior aorta; *Mu* lateral muscles, the contractions of which assist the heart in dilating and sucking in blood-fluid through the valves. The blood thus flows in the direction indicated by the arrows (p. 445f).

FIG. 2.—Diagrammatic view of heart and adjoining parts of the circulatory system of a fish, from the ventral aspect. The parts which conduct venous blood i.e. blood laden with the products of metabolism) are marked by a darker shade than those conducting arterial (i.e. purified) blood; the direction in which the blood flows is indicated by small arrows. A general description of the conditions shown in the drawing is given on page 452; it may here be added that, for simplicity's sake, the connections between the afferent and efferent branches (*Aff* and *Eff* respectively) of the aortic arches are only represented (diagrammatically!) in the upper left-hand corner of the drawing. We there see, in the second arch from the top and marked [*Gi*], a small vessel leaving the afferent branch, describing an outward loop, and entering the efferent branch. Such a loop is found in each of the leaflets which compose the gills and give them their fringe-like appearance (p. 6); the real conditions thus becoming similar to those represented in the top-branch of the left side, where an attempt has been made to show all these loops. It is a consequence of this arrangement that every afferent branch, by sending off one loop after the other, gradually diminishes in diameter and finally ceases altogether, while the corresponding efferent branch is as gradually built up by the loops which, on returning, one by one fuse to form it (hence the separate course of afferent and efferent branches visible on the right-hand-side of the drawing). *Vt* the simple ventricle, from which the ascending aorta arises in a sharply marked onion-shaped swelling—the aortic bulb; *At* the simple atrium, to the sides of which the big veins are seen, which bring the venous blood back from the body.

FIG. 3.—A gill-leaflet, isolated and looked at from its flat surface. We here see in *Aff* an afferent branch of the aortic arch in optical cross-section; a loop leaves it in an upward direction and returns on the other side, there to enter the efferent branch *Eff*. During this course it becomes dissolved (as indicated diagrammatically) into a rich system of capillaries within which the blood has ample opportunity to give off its carbon-dioxide and take up oxygen in exchange.

FIG. 4.—Heart and adjoining parts of the circulatory system of a tadpole, diagrammatically shown from their ventral aspect. All constituent parts are still quite symmetrically developed, so that those cut away on the right-hand-side of the drawing would have been the same as those actually shown on the left-hand-side; the shading and marking by arrows have the same significance as in Figure 2. An explanation of the conditions depicted is given on page 456f; note in particular the presence of the communication + in each of the three anterior aortic arches; a communication, through which a part of the blood can flow directly to the descending aorta, while another part must go through the side-branch into the gills (*Gi*), there to be brought into intimate contact with the surrounding water through a system of similar capillaries as was described in Figure 3. The hindmost (fourth) aortic arch is seen to have no communication with gills. The heart, composed of a simple ventricle (*Vt*) and a simple atrium, is still quite similar to that of the Fishes (compare Fig. 2).

FIG. 5.—Heart and adjoining vessels of a fully developed frog, seen from the dorsal side. A portion has been cut away as in the preceding figure; the rest has been arranged in such a way that the various constituent parts of the adult circulatory system lie, in the median line, each opposite that part of the larval circulation from which they developed; for the sake of better comprehension, the tracks which became entirely reduced during



metamorphosis are also indicated in faint shading. We thus see (compare p. 457) that the second aortic arch of the larva persists as a whole and becomes the (sole existing) aortic arch *Ao* of the adult; that the first and third larval aortic arches disappear almost entirely in the adult, and that the fourth aortic arch of the larva, while it loses its connection with the descending aorta, becomes the pulmonary artery *PA* of the adult. The pulmonary vein *PV* is a new formation which, after union with its mate of the other side, enters the left part *LA* of the atrium now divided into two. The purified blood from the lungs thus has to go through the left atrium, the undivided ventricle, and the aortic arch *Ao* to the body (note the differences in the shading, which mean the same as in Figs. 2-4); from this, it returns, laden with the products of metabolism, through three chief veins (two anterior, one posterior, as visible in the drawing) and now enters the right part of the atrium *RA*, from which, however, it must again pass through the undivided ventricle, to be sent by this through the pulmonary artery to the lungs.

FIGS. 6-9.—To illustrate the discussion of the relations between circulatory and excretory systems of the Metazoa (pp. 458-464).

FIG. 6.—A “vibrating funnel” from the excretory system of Trematodes, highly magnified (compare p. 459). The thin excretory canal is somewhat widened at its end and closed by a cell, a process of which extends into the funnel-shaped widening. This process, by constant undulatory movements, causes the contents of the vessel to move on in an outward direction.

FIG. 7.—Diagram of a nephridium of an earthworm (compare *Nph*, Fig. 1, Pl. XXIV), highly magnified (for description see p. 460). *NSt* the nephrostome, or nephridial funnel, situated on the upper side of the dissepiment *Di*, while the whole rest of the organ is situated on its lower side (p. 472). It represents a fairly thick, irregularly sausage-shaped mass of excretory cells, within which the long thin excretory canal *Can* describes a number of loops; its terminal portion is somewhat widened and, after leaving the cellular mass, swells up into vesicular receptacle which opens outward by the pore *Op* (this latter seen in its natural position between the dotted lines of *Nrv* and *LM* in Fig. 2, Pl. XXIV).

FIG. 8.—Diagrammatic picture showing in surface-view, above the break opposite the numeral 8, the pronephros, below the same break, the mesonephros of certain Amphibia. The pronephros (p. 460f) is composed of four nephrostomes *NSt* connected by comparatively short, wide ducts with the pronephric canal *PNC*; the mesonephros (p. 462), developing after, and lying behind, the pronephros, is composed of a large number of nephrostomes *NSt*, continued into long thin nephridial canals which, after a fairly tortuous course, open into the continuation of the pronephric canal, and thereby transform it into the mesonephric canal *MNC*. The pouches they send out to receive the glomeruli appear in the drawing as mere dark round bodies *Gl*, but are more clearly seen in Figure 10, Plate XXII.

FIG. 9.—Part of the mesonephros of certain fishes, highly magnified (compare p. 463). We here see the mesonephric canal *MNC* and two nephridial canals starting from it. One of the latter, drawn in full, dilates into the usual pouch which receives the glomerulus *Gl*, but there is no longer any communication with the abdominal cavity by a nephrostome; the respective canal being reduced (as indicated in the drawing by the brackets [] round *NSt*) to a short blindly closed bulging of the pouch. *BV* the blood-vessel which enters the pouch and, after having formed the glomerulus *Gl* by breaking up into capillaries, leaves it in the opposite direction.

FIGS. 1-4.—To illustrate the chapter on the earthworm, pages 469-474.

FIG. 1.—An earthworm slit open, with the exception of its extreme cephalic end, along the mid-dorsal line, and the internal organs exposed to view by flattening out the lateral body-walls. These latter thus present to the observer their inner surface, i.e. the inner (longitudinal) fibres of the dermo-muscular coat (p. 469), as indicated in the drawing by the longitudinal striation. A large posterior portion of the body has been cut away; the various organs which lie below one another in the median plane being shown in such a manner that they present their cut ends one behind the other at the lower end of the drawing. The upper end shows a few cephalic segments from their outside; we notice that the constrictions which separate them correspond, inside, to the dissepimenta *Di* (p. 470), which thus mark off the segments internally. All segments are fairly uniform both in length and internal organisation (as is characteristic of the metameric architecture, pp. 231, 465f). So we see, in each segment, a pair of nephridia *Nph* and, behind these, on either side two small round bodies *Se* which represent the inner ends of the pouches harbouring the setæ (*Se*, Fig. 2). The middle of the drawing is occupied by the intestine *In*, the several subdivisions of which—products of a division of labour after the same principle as was explained on page 28f—are not however separately marked. Above and below the intestine lie the two chief longitudinal blood-vessels; of these, the drawing shows the dorsal vessel *DV* fully exposed to view, while of the ventral only the cut end *VV* appears just below and behind the cut end of the intestine. In connection with the dorsal vessel we further notice, anteriorly, the five pairs of lateral loops *H* which function as hearts, and, posteriorly, the first three of those lateral communications between dorsal and ventral vessels, which thenceonward occur one in every segment and also seek the peripheral organs (p. 471); the drawing only shows their places of entrance into the dorsal vessel. Of the nervous system, owing to its quite ventral position, the dissection only allows the supra-oesophageal ganglia *SoG* to be recognised anteriorly, and the cut end protruding at *Nrv* from under the intestine and the ventral vessel *VV* posteriorly (compare however Fig. 2). The genital organs are marked, the male organs ♂; the female ♀.

FIG. 2.—Diagrammatical cross-section through a segment behind the genital organs. We may here distinguish, first of all, body-wall and body-cavity. The former is represented by the dermo-muscular coat, and composed of the epidermis *Ep* and two layers of muscle-fibres, a circular one *CM* and a longitudinal one *LM* (p. 469). Embedded in the coat we see four groups of setæ *Se* functioning as subsidiary organs for locomotion (p. 470); to the right and between the dotted lines of *Nrv* and *LM* the coat is perforated by the excretory duct of the nephridium *Nph*; this latter itself being situated in the body-cavity (compare also Fig. 7, Pl. XXIII). The corresponding nephridium of the left side has been omitted, in order to more clearly show the vessels which, in their turn, have been omitted on the right side. The middle of the body-cavity is occupied by the intestine *In*, the wall of which, from the mid-dorsal line, projects somewhat into the lumen in the shape of the incomplete partition-wall visible in the drawing. Above and below the intestine, we perceive the cross-sections of the two chief longitudinal vessels *DV* (dorsal vessel) and *VV* (ventral vessel); their lateral connections, with each other as well as with the organs of the body, are however more complicated in reality than they appear in the drawing, in which the chief stress has been laid on the connection between circulatory and respiratory system—the latter in this case represented by the skin (pp. 448, 471). So we see that the lateral arch leaving *VV* does not go straight to *DV*, but approaches the body-wall and penetrates into it in a large number of fine capillary spaces *SdV* representing subdermal vessels; not until these have returned and coalesced again into a common track do they seek the dorsal vessel. Below the cross-section of the nervous system *Nrv* the figure still shows, marked + as in Fig. 1, the cross-section of another longitudinal vessel known as subneural vessel; it communicates with the dorsal vessel, as visible in the drawing, while its connections with the remaining organs of the body have not been taken notice of.

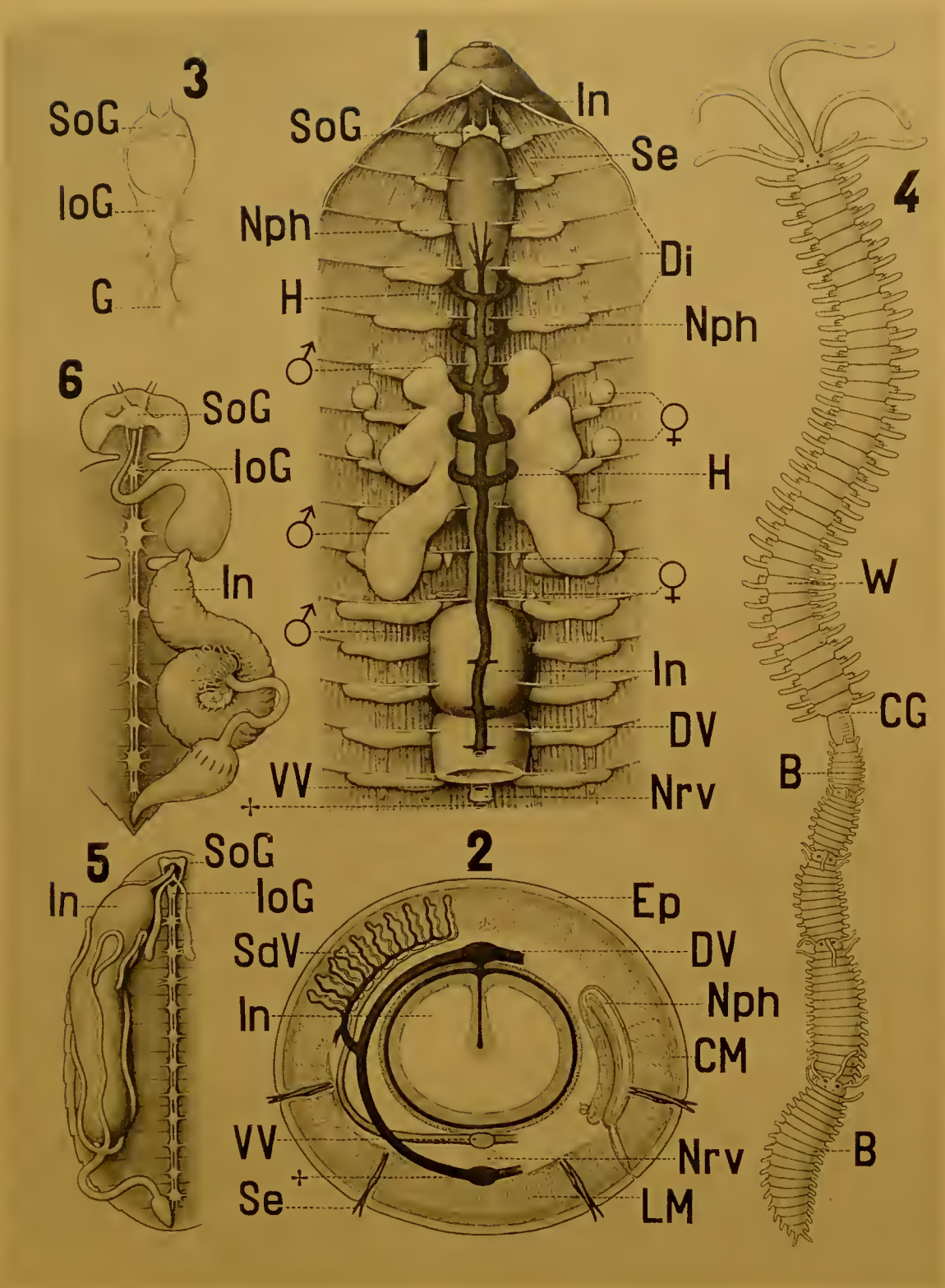


FIG. 3.—Anterior portion of the nervous system, dissected and seen in surface-view. There is the nerve-collar, formed by the supra-oesophageal ganglion *SoG* transmitting on either side, and round the intestine (compare *SoG*, Fig. 1), a cerebral commissure to the infra-oesophageal ganglia *IoG*. These latter are followed by the chain of the ordinary ganglia *G* which belong one to every body-segment (metameric architecture!) and there send out peripheral nerves to the various constituent organs of the segment.

FIG. 4.—Sketch of a marine representative of the earthworm supplying an example of those peculiar methods of asexual reproduction alluded to on page 474. *W* the body proper of the worm, composed of a head (with eye-spots and tentacles) and a number of segments; the latter all presenting the same outward appearance. At its posterior end this body has a centre of growth *CG* which, when it becomes active, by cellular multiplication produces a small bud in a backward direction. The bud increases in size and, while so doing, becomes segmented and develops a head at its anterior end. The centre of growth, meanwhile, has produced a new bud which, as a matter of course, is interposed between the end of the parent worm and the first bud *B*. The new bud henceforward behaves as the first, and while they both continue to grow a third bud is formed, and so on. After this fashion the specimen depicted has produced a chain of six young worms, of which the terminal one (*B*) is the oldest, the one immediately behind the centre of growth the youngest. They eventually all break asunder and then represent daughter-individuals asexually produced by budding.

FIGS. 5, 6.—Sketches to illustrate some of the internal changes which take place during the metamorphosis of the bee (pp. 192, 232).

FIG. 5.—The chief internal organs of a bee-larva, dissected after the method described in Fig. 1. In the middle, and lying against the ventral surface of the body-cavity, we perceive the nervous system, beginning with a nerve-collar quite similar to that of the earthworm (Fig. 3). The chain of ganglia which follows extends through nearly the whole length of the body, each segment, with the exception of the last, having its own ganglion. The digestive tract which normally lies in the middle of the body, but in this position covers the nervous system, has been displaced to the left in the dissection. It begins with a short thin oesophagus encircled by the nerve-collar; the two short tubes which appear below it are salivary glands homologous to those of the mosquito (Fig. 12, Pl. XIII) and the spinning glands of the silkworm (p. 188). The long thick tube marked *In* is the stomach; it seems to be continuous with the thin intestine that follows, and eventually opens through the anus at the end of the body after having previously formed a slight swelling. In truth there is no continuity between the lumina of stomach and intestine; the latter only serves as outlet for four long thin tubes, three of which are seen in the drawing to lie against the wall of the stomach. They are the excretory organs of the bee-larva.

FIG. 6.—The chief internal organs of the full-grown bee. Note the changed appearance of the chain of ganglia, of the oesophagus, the stomach, and the terminal swelling of the intestine; the excretory tubes, in addition, while they decreased in size, have increased in number; the stomach and intestine, finally have now established a communication of their lumina. A comparison of this organisation with that of the larva shows that the metameric architecture, though still recognised clearly enough, is yet less pronounced than it was in the larva (p. 232).



